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INVESTIGATION OF A METHOD FOR REPAIRING THE HOT GAS SYSTEM BRANCH II OF THE SYMPHONIE-SATELLITE MV2 IN ORBIT

FINAL REPORT

by

H. BRAUN

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MBB (Messerschmeitt)Boelkow-Blohm Report

February 13, 1978

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1. Summary

1.1 Process

Anomalies have occurred in the Symphonie Satellite MV2 on the hot gas system branch since May 1976, which in part have led to the failure of all engines, that is, engines no. H2, H4, H5.

Analysis of the Process

A detailed analysis of the phenomena has led to the conclusion that the fuel supply for the engines has been interrupted by some kind of blockage at one point of the conveyance system. Also the analysis performed has led to the conclusion that out of the two supply systems for oxidizer and fuel, the oxidizer system is blocked. This conclusion resulted from the fact that after turnoff of the engines, a thrust was delivered after a certain time without opening any fuel valves.

This phenomenon can be explained by the fact that during the previous regular activations of the engines, only fuel flowed out, which is frozen solid because of the fact that there is no combustion heat in the combustion chamber, and at a later time it was thermally decomposed by the oxidizer which was supplied in drops. From the process described here we can conclude that the oxidizer branch is blocked.

1.2. Possibilities of Repair

It is known that for certain pre-conditions, so called metal salts are formed in the oxidizer which first are present in the dissolved state. These metal salts can precipitate at the high speed of the solution medium, that is, through the narrow passages of the conveyance system in a jelly-like solid form (gel). This leads to further constriction of the narrow passage and leads to complete blockage. It is natural to look upon this phenomenon as the cause of blockage of the oxidizer branch of the MV2.

An evacuation of the oxidizer branch is the only method of repairing the device in orbit. Therefore, we first carried out laboratory experiments where we observed the behavior of artificially produced jellies in a vacuum (1 Torr). It was found that the solid volume of the jelly is reduced, which is to be attributed to a sublimation. This gives us a first indication that there is a possibility of repairing the oxidizer branch in orbit. In order to estimate the effectiveness of the vacuum on the removal of jellies under these boundary conditions which prevail for the conveyance system, we performed further analyses to determine which simulations would be possible on the ground.

Simulation Methods on the Ground

In several discussions with representatives of the individual with the individual institutes such as CIFAS, GESOG, CNES we defined the simulation method on the ground. We fix the following:

The raw material for the jellies is manufactured artificially by mixing water, Kaltron and Iron Nickel nitrate to N_2O_4. The following composition has been specified 98 % N_2O_4, 1 % H_2O and 1 % Kaltron 113 and 20 mg 50/50 FE-Ni Nitrate. Water and Kaltron were added because one cannot exclude that these media have remained in the bellows tanks which are difficult to clean. A non-contaminated fuel MMH together with this contaminated oxidizer was used to operate a 10 N-engine under hot run conditions using an original replica of the conveyance system up to the systems valve. The test configuration was selected in this way because the critical passages in the components after the system valve such as the filter, diaphragm and engine exist in it. The simulation of the blockage was carried out in conjunction with a hot run, because only in this way can one simulate the flow conditions in the conveyance system which exist in orbit.

We can assume that the operational conditions for the simulation method created in this way agree for the most part with the oxidizer branch in orbit. However, as far as the simulation of the contaminated fuel is concerned, we have to refer to estimates only. This uncertainty is only of secondary importance for the simulation tests on the ground, because we're not interested in examining the possible blockage, but instead we wish to investigate the possibility of removing an existing blockage using a vacuum.

1.4. Test Configuration

An original hot gas system (see appendices) was built from the system valve up to the engine. Filters, diaphragms and pipelines were newly constructed according to the available data sheet of the Symphonie project. The ten N-engine already had an operating time of 2148 seconds. Since jelly formation is accelerated at narrow passages by low fuel temperature, the entire conveyance system was installed in a basin filled with ice water. This way we satisfied the condition that already after a short operating time we could expect a blockage of the conveyance system. At the critical passages of the conveyance system such as the filter, diaphragm, engine valve with filter and the injection system of the engine, we installed measurement connections for measuring differential pressure, in order to be able to record a change in the cross sectional passage area brought about by the beginning of the blockage (see schematic diagram of the test configuration). In order to be able to evacuate the conveyance system after the hot run in the blocked state, we manufactured an adaptor with which the expansion nozzle of the engine.

In the second test series we wish to examine whether the removal of the blockage is possible for those components which lie far away from the evacuation point, by extending the duration of the evacuation,

EVACUATE CONVEYANCE SYSTEM
4×10^{-3} Torr AT
23 - 26 °C for
72H

HOTRUN 1.3
WITH CONTAMINATED
N_2O_4 BLOCKED
AFTER 400 SECONDS

HOTRUN 2.1
REFERENCE TEST WITH
NON-CONTAMINATED
N_2O_4
1400 SECONDS

HOTRUN 2.2
WITH CONTAMINATED
N_2O_4, BLOCKED AFTER
360 SECONDS.

CONVEYANCE SYSTEM
EVACUATION
5×10^{-3} TORR
28 - 29 °C FOR
285 Hours

HOTRUN 2.3
WITH CONTAMINATED
N_2O_4, N_2O_4 - TANK
EMPTY, NO CRITICAL
BLOCKAGE AFTER
1285 SECONDS

TANK IS REFILLED
WITH CONTAMINATED
N_2O_4 FOR
1000 SEC OPERATING
TIME

HOTRUN 2.4 WITH CONTAMINATED N_2O_4
BLOCKED AFTER 99 SECONDS.

1.6 Test Results

Except for the hot run 2.3, a blockage was achieved with contaminated N_2O_4 after an operating time of about 400 .econds, which made it necessary to break off the hot run. The oxidizer throughput progressively was reduced,and at the same time the fuel throughput was increased because of a reduction in the combustion chamber pressure. The hot run was then terminated because due to the extreme displacement of the mixing ratio and the reduction in the total throughput, the combustion in the engine became extremely unstable and liquid unburned fuel came out of the engine.

The manner in which the blockage comes about can best be seen by investigating the variation of the flow number (FN). The flow number is a measure for the penetration cross section. It can be seen that cross section reduction per unit time in the filter is the greatest. From this we can conclude that the flow speed in the filter is very high and therefore a strong jelly formation occurs. In this way, already most of output products of the gels are held back by the filter. Therefore in the following narrow passages the cross-section reduction is much slower than in the filter. The cross-section reduction in the narrow passages which are switched into the filter indicates that these are really jellies and not solid particles which produce the blockage. This is because the fineness of the filter is selected so that particles which can still pass the filter are so small that they cannot bring about any blockage in the following narrow passages. The most important result of the tests is the fact that by evacuation, the blockage of the narrow passages can be reversed again. It is of interest in this connection that the removal of a blockage,that is the removal of the jellies, depends on the time over which the vacuum ac... For example, Test 2.3 shows that the blockage also can be removed completely at the point which is farthest away from the evacuation point, that is, the filter.

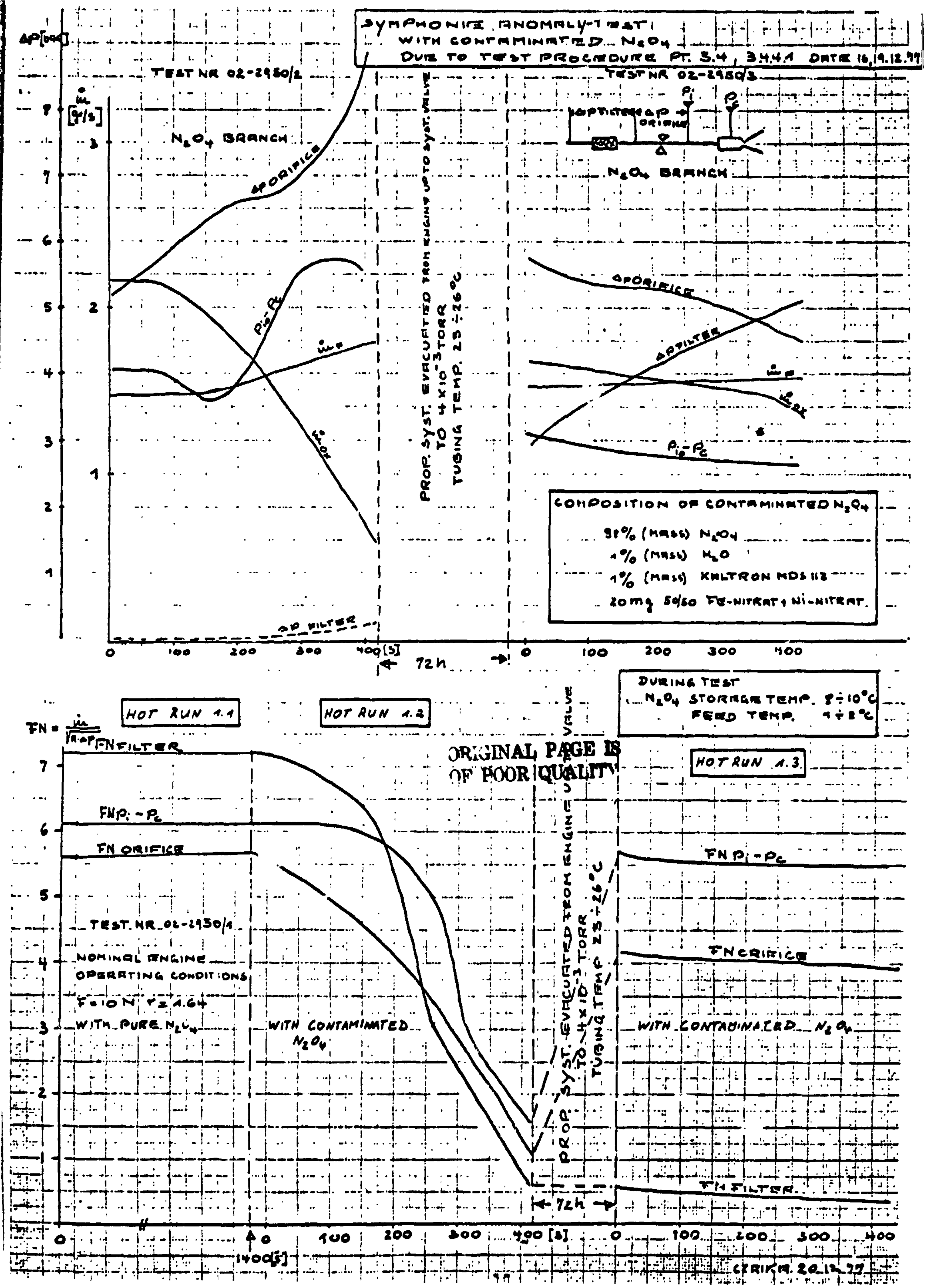
1.7 Final Conclusion

Ground tests have shown that a removal or at least a reduction of the blockage of the oxidizer branch is possible by evacuation. If one follows the test results further, we have to conclude that the greatest blockage occurs in the filter. This then results in a restriction in the capability to perform repairs to the oxidizer branch in orbit. This is because the filter installed ahead of the system valve cannot be subjected to a vacuum.

2. GRAPHS OF TESTS RESULTS

- Test Series 1, Tests 1 - 3 (1 Sheet)

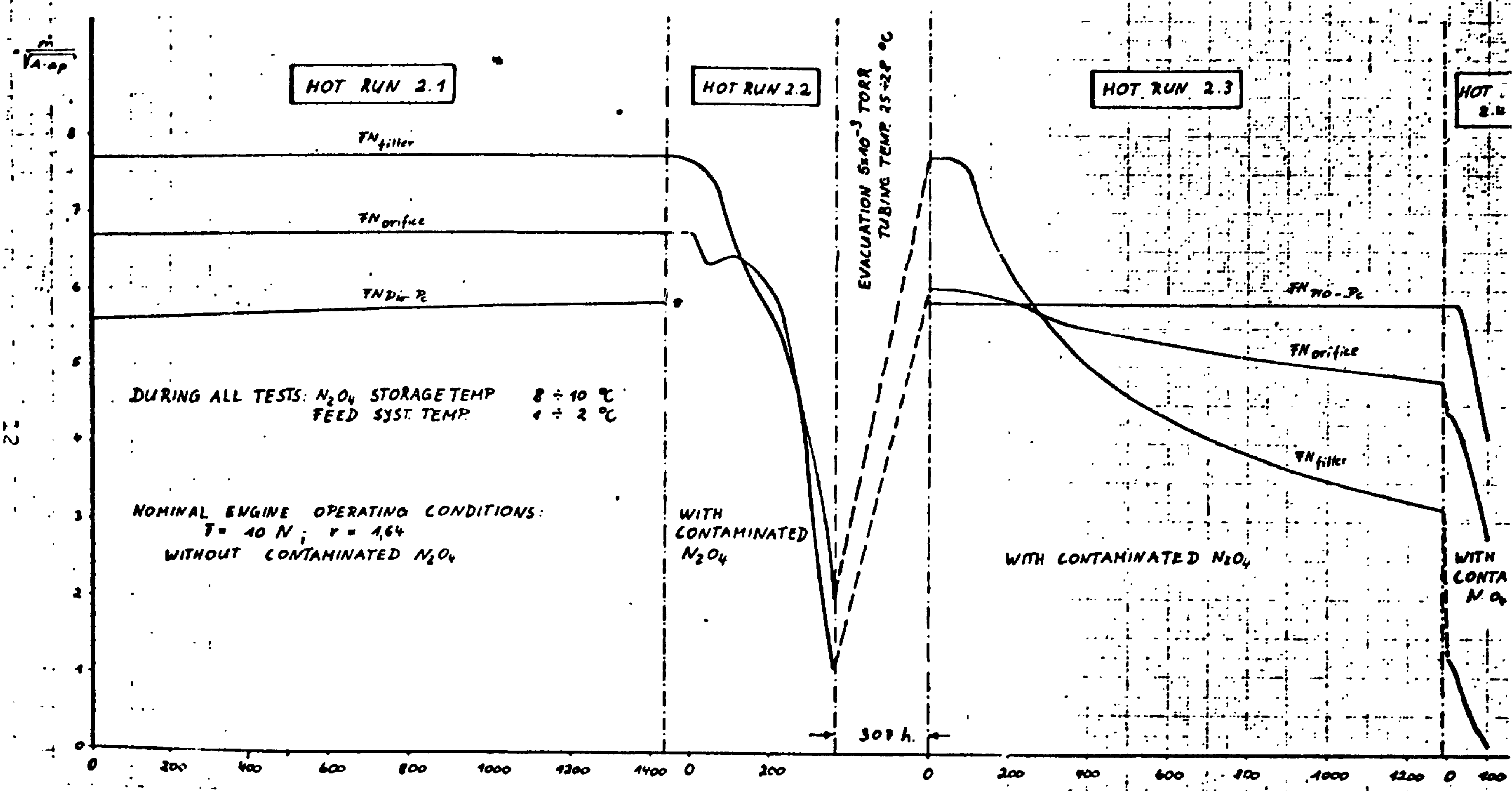
- Test Series 2, Tests 1 - 4 (2 Sheets)


SYMPHONIE ANOMALY-TEST
WITH CONTAMINATED N_2O_4
DUE TO TEST PROCEDURE PT. 3.4, 3.4.4.1 DATE 16,19.12.77
TEST NR 02-2950/2
TEST NR 02-2950/3
N_2O_4 BRANCH
ΔP ORIFICE
$P_i - P_c$
ΔP FILTER
PROP. SYST. EVACUATED FROM ENGINE UP TO SYST. VALVE TO 4x10⁻³ TORR TUBING TEMP. 23÷26°C
72h
ΔP FILTER
COMPOSITION OF CONTAMINATED N_2O_4
98% (MASS) N_2O_4
1% (MASS) H_2O
1% (MASS) KALTRON MDS 113
20mg 50/50 FE-NITRAT + NI-NITRAT
DURING TEST
N_2O_4 STORAGE TEMP. 8÷10°C
FEED TEMP. 9÷2°C
HOT RUN 1.1
HOT RUN 1.2
HOT RUN 1.3
FN FILTER
$FN\ P_i - P_c$
FN ORIFICE
TEST NR 02-2950/4
NOMINAL ENGINE OPERATING CONDITIONS
F = 10N r = 1.64
WITH PURE N_2O_4
WITH CONTAMINATED N_2O_4
PROP. SYST. EVACUATED FROM ENGINE UP TO VALVE TO 4x10⁻³ TORR TUBING TEMP. 23÷26°C
WITH CONTAMINATED N_2O_4
1400[s]
CZRIKA 20.12.77

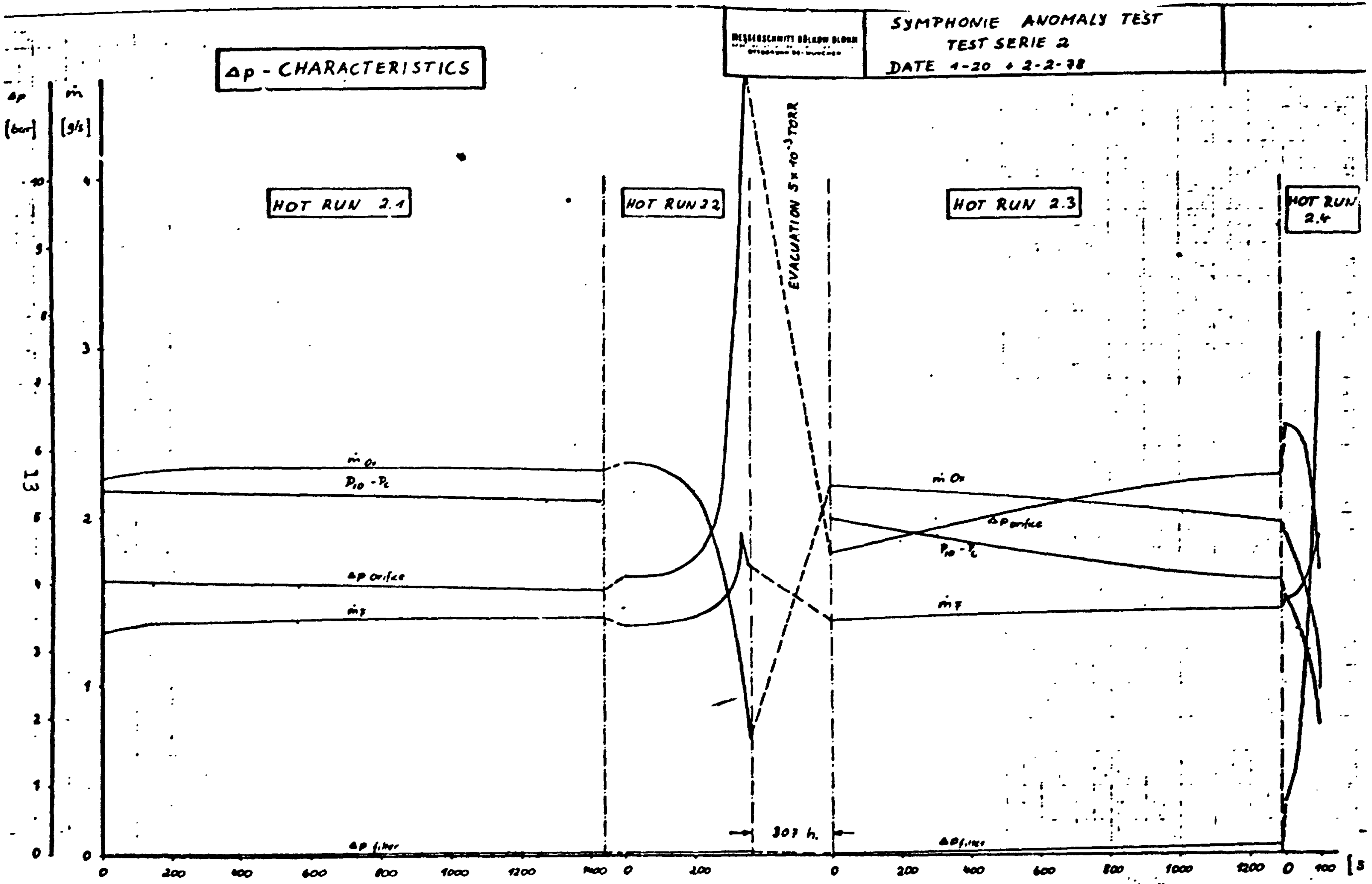
MESSERSCHMITT BÖLKOW BLOHM

SYMPHONIE ANOMALY TEST
TEST SERIE 2
DATE 1-20 ÷ 2-2-78

FN-CHARACTERISTICS



* $P_{IO} - P_c$ - MEASURING FAILED BY CLOGGING P_c MEASUREMENTPORT



SYMPHONIE ANOMALY TEST
TEST SERIE 2
DATE 1-20 + 2-2-78
MESSERSCHMITT-BÖLKOW-BLOHM
Δp - CHARACTERISTICS
HOT RUN 2.1
HOT RUN 2.2
HOT RUN 2.3
HOT RUN 2.4
EVACUATION 5 x 10^-3 TORR
307 h.
ṁ Ox
p10 - pc
Δp orifice
ṁ F
Δp filter
Δp [bar]
ṁ [g/s]
[s]

3. GROUND TESTS FOR INVESTIGATING THE MV-2 ANOMALIE

TN-RT35-7/77

Distribution:

RX 26	- H. Schwanda
RT 353	- H. Braun
RT 35	- H. Munding
RT 351	- H. Lammers
	- F. Kail

MBB Report: TN - RT 35-75/77

Author: Munding, German

Subdivision: UR / RT 35

Title: Ground Tests for Investigating the MV_2 Anomalie

Report Size: 20 Pages

Date: November 4, 1977

Reference:
Appendix 1, TN RT 353-1/77 of November 3, 1977

Table of Contents

Definition of the tests according to the protocol of October 13 1977 with the experts at Lampoldshausen.
- Point 3 of the discussion protocol.

1. INITIAL CRITERIA

1.1 What Kind of Contamination is Present?

- Reaction product between contaminated N_2O_4 and the tank materials V_2A and Titanium.

- Impurities in the N_2O_4 can be caused by humidity or residual amounts of freon (Simulation liquid). Both components favor the formation of salts (Fe - and Ni-nitrate) $NO_3^- + Me^+ \longrightarrow Me\,NO_3$

1.2. What quantitative amounts of corrosion products leads to a blockage of the conveyance system?

1.3 At which point of the conveyance system did blockage occur?

2. TEST CONFIGURATION

The following experience and knowledge has to be applied for the design of the test configuration and execution;

2.1 The blockage does not occur suddenly but gradually and progressively.

2.2 The higher the temperature of the N_2O_4, the more Fe and Ni-nitrates can be held in solution without precipitation in the form of solids.

2.3. The higher the flow speed of the fuel, the greater will be the tendency for the Fe and Ni-Nitrates to precipitate as solids out of the solution.

From the initial criteria, experience and knowledge we can derive boundary conditions for the test configuration and execution.

In order to have a direct means of comparison with processes in the original system, it is simulated as much as possible in the test configuration as allowed by the blockage criteria.

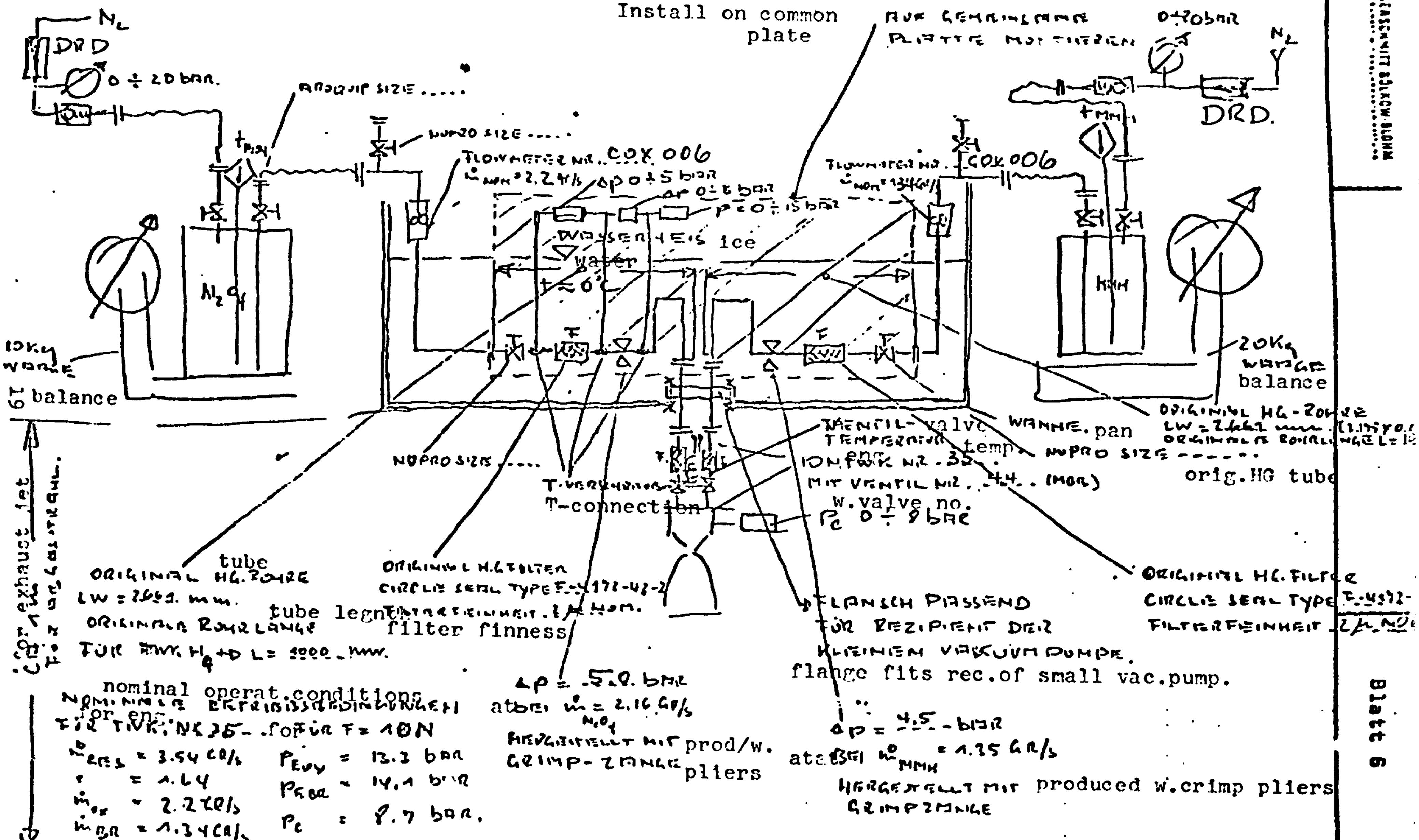
3. DEFINITION OF THE CONTAMINATED N_2O_4

In the definition of the contaminated N_2O_4 solution we assume that the water content as well as the freon content cannot cause the blockage directly, but only indirectly by the increased formation of Fe and Ni-Nitrates. However since the formation of Fe and Ni-Nitrates is a long time process because of the water content and the freon content and the experiments have to lead to a result as fast as possible, the amount of Ni and Fe Nitrate is added directly to the N_2O_4

N_2O_4 solutions are produced which have a constant degree water and freon contamination, but their Fe and Ni nitrate amounts are increased until blockage occurs. Since the blockage already occurred at the beginning of the mission, the Fe and Ni nitrate amount can be selected so high that blockage already is present for a flow amount of 3 kg solution.

4. TESTAUFBAU.

TEST CONFIGURATION



5. DESIGN CRITERIA FOR TEST CONFIGURATION

5.1 Instead of folding bellows containers we used tank filling containers.
The reason: The N_2O_4 container has to be filled with N_2O_4 with different nitrate content for each test. The folding bellows tank is not suitable for these tests, because complete cleaning cannot be guaranteed and therefore the defined salt content cannot be determined with certainty.

5.2. In order to reduce costs, instead of He, N_2 is used to pressurize the fuels. The influence of dissolved gas in the fuel on the formation of blockage products is assumed to be small compared with the effect of the mixed amounts of Fe and Ni-nitrate.

5.3 The operation of the engine is done at a constant tank pressure in contrast to blow-down operation in the original hot gas system. Reason: a possible reduction in the throughput due to the beginning of blockage can be controlled much more poorly for blow-down operation.

5.4. The test configuration has flow meters in order to be able to adjust the nominal throughput amounts $\dot{m}_{gas}$ (total) and the mixing ratio r without difficult adjustment procedures. This is done by simply changing the tank pressures at the beginning of each test.

5.5 In the N_2O_4 supply system in which the blockage is expected the pressure losses in the filter, in the diaphragm and in the injection system of the engine are checked by measuring Δp .

5.6 The entire fuel conveyance system except for the fuel containers is surrounded with ice water in order to guarantee a constant fuel temperature, especially for N_2O_4 from one test to another. It is small enough so that any blockage that occurs can be accelerated. The fuel conveyance system is submerged in a pan.

5.7 The conveyance system from the Nupro blockage valve up to the engine corresponds to the original conveyance system in length, armatures, such as filters and adjustment diaphragm and also with respect to flow cross section. The pipelines which lead through the flange are an exception to this.

5.8 Between the engine and the conveyance system there is a flange which is suitable for serving as a covering flange of the recipient. In this way after blockage has occurred in the engine, it can be evacuated without separating the conveyance system. During the blockage test, the flange at the same time serves as a sealing flange with respect to the water pan. The flange has to be installed so that the engine with the conveyance system can be disassembled from the water pan without being taken apart. The connections of the flange conveyance lines which have thick walls and are made with 3 - 4 mm lW are made by means of bolts with respect to the conveyance system on the one hand and the engine on the other hand (ANR-DIN bolts) connections.

5.9. The conveyance system up to the separation points at the Nupro valves is mounted on a plate in order to be able to transport it together with the engine to the vacuum pump.

6. WORKING PLAN

6.1 Cleaning of the containers and cleaning of all of the components of the conveyance system.

We have to distinguish between parts which have already been contaminated with fuels and newly produced parts. The latter are cleaned according to TN RT 353-1/77, (see Appendix 1), Item 3.2 including and up to Item 3.3. For already contaminated parts, for example the HG-Symphonie tank filling container, cleaning is also done according to TN RT 353-1/77, Item 3.3. For cleaning purposes the flange is removed from the tank and the inner wall is sprayed with a spray nozzle having a hard jet. The tank is placed with the flange opening toward the bottom. The container is closed and evacuated with simultaneous heating from the outside (20 minutes). After this the insulation is flooded with N_2 (penetration of air is avoided). Empty weight of the container is determined with the final equipment installed.

6.2 Filling of the N_2O_4 Container

Distilled N_2O_4 is filled in through 2 μ Millipore-Filters and the filling is controlled by weighing. Then it is ventilated and the containers are first opened, in order to avoid the entry of air, if overpressure already exists in the container. N_2O_4 containers are then finally connected to the test configuration.

6.3. Filling of MMH Containers

MMH is filled in cleaned Symphonie hot gas tank-filling containers. MMH is filled in through 2 μ Milliporefilters. Otherwise the same procedure is used as for the

N_2O_4. containers.

7. PRODUCTION OF THE CONVEYANCE SYSTEM

7.1 All of the components of the conveyance system

- Aeroquip-hoses
- Nupro valves
- flow meters
- pipelines
- screw connections
- pressure transducers

are cleaned according to TN RT 353-1/77, except for the engine with the valve. The conveyance system is assembled under clean conditions.

7.2 The adjustment diaphragm is not adjusted with original fuel but with water instead, and the equivalent amount is calculated according to

$$\frac{\dot{m}_{Ox}}{m_{H_2O}} = \sqrt{\frac{Ox}{H_2O}}$$

for equal Δp .

7.3 All of the connections are made using DIN-Screw connections, and the capillary tubes are welded into the nipples.

7.4 A "constant" power supply can be used for the engine valve and a rocking switch may be used for control.

8. AMOUNTS OF FUEL TO BE FILLED

- Content of the fuel-filling container 7.5 liters
- The N_2O_4 container is filled with the amount required for a single test.
- The MMH-container is filled until the amount is suf-

ficient for all tests.

- Tank filling amount for MMH-container 7 lit ≙ 6300 gr
- Useful amount 6,5 lit ≙ 5850 gr

Assumed number of tests: 3

MMH-amount per test: 1950 gr

N_2O_4 amount required for this 3198 gr

Total amount 5148 gr

The required testing time is calculated from

$$\frac{5148}{3.54} = 1454 \text{ s} \;\hat{=}\; 24 \text{ min}$$

Summary:

Amounts to be filled;	MMH	6300 gr
	N_2O_4	3500 gr

Test time to be expected per test: 24 min

9. TEST SEQUENCE

- Filling of the fuel amounts
- Calibration of transducers
- Hermeticity test for the entire conveyance system
- Functional test of the engine valve
- Filling of the pan with ice water
- Evacuation of the N_2O_4 conveyance system with closed tank valve and opened system valve
- pressurization of the N_2O_4 container at p_T

$$\begin{aligned} p_{E\,N_2O_4} &= 13{,}3 \\ \Delta p_{Bl} &= 5{,}0 \\ \Delta p_{Rohr} &= 0{,}5 \\ \hline p_T &= 18{,}8 \text{ bar} \end{aligned}$$

- filling of the N_2O_4 conveyance system by opening tank valve.
- Taking of a cleanness sample with a millipore-adaptor with a 2μ filter and a flow amount of 200 grams
- Qualitative check of the filter for particle amount, particle size and particle identification.
- Evacuation of the MMH conveyance system with a closed tank valve and open system valve
- Filling of the MMH conveyance system by opening the tank valve
- Manual recording of the fuel temperature in the tanks
- Manual recording of the tank pressures

$$p_T = P_{Mano} - 0{,}3 \text{ (RV)}$$

- Manual recording of the ice water temperature
- Equalization of the differential pressure transducers
- Manual recording of balanced readings
- Operation of the engine for 24 minutes
- Check of the mass throughputs using the flow meter readings. If necessary discontinue engine operation and make a throughput correction by changing the tank pressure, if there are deviations in

$$\dot{m}_{ges\ Nom}\ (\text{Total}) \quad \text{and} \quad r_{Nom}$$

- Observations of differential pressures, injection pressure and flow meter readings in order to evaluate whether a possible reduction of the throughputs is caused by the beginning of blockage in the case where throughputs are reduced.
- Observation of the temperature loaded on the engine, especially on the vacuum nozzle and interrupt test for any critical operational test.
- Let any blockage increase in the N_2O_4 system as long as the operating state of the engine does not become critical because of the displacement of the mixing ratio.

- After blockage of N_2O_4 has occurred
  Conveyance system (reference value $\dot{m}_{N_2O_4} < 20\ \% \cdot \dot{m}_{N_2O_4\ Nominal}$
  Discontinue operation

- Determine the location of the blockage (filter, diaphragm injection system) from the changes in the differential pressures which have occurred or from the injection pressure.

- Close the tank valve (Ox/Br) (oxidizers/fuel) and the N_2O_4- system valve

- Rinse the MMH conveyance system with N_2 with an open engine valve by pressurization through the pressure relief valve of the MMH conveyance system and for closed MMH system valve.

- Remove ice water and take out the conveyance system together with the engine from the water tank.

- With a pre-vacuum, remove fuels from the engine and the conveyance system as much as possible by connecting a water spray pump to an adaptor (plate with a rubber sealing plate) to the vacuum nozzle of the engine.

- Install the engine with connected conveyance system to the recipient of the vacuum pump.

- Open the engine valve and evacuate the conveyance system for 48 hours (10^{-2} Torr) . Temperature of the engine valve should be checked. First record every 10 minutes. Close the engine valve when 95°C is exceeded and open it again when t temperature drops. Record vacuum pressure.

- Reinstall the conveyance system in the test assembly.

- Repeat the hot run test. Record the throughputs and pressures to check whether the degree of blockage has been reduced by the evacuation. The tank pressures in the previous step are maintained.

- If it is not successful to remove the blockage, the conveyance system is rinsed through a 2μ filter with distilled water at a temperature of about 60°C. The rinsing water is captured in a clean container.

10. SPECIFICATION OF THE N_2O_4 FOR THE INDIVIDUAL TESTS

10.1 Test 1

Reference test for which no blockage is expected.

Distilled N_2O_4 with the following composition:

		Nominal values according to MIL-spec 26539C	Actual values
N_2O_4	Weight wt%	≤ 99.5	99.99
H_2O	Equivalent wt%	≤ 0.17	0.11
Solids	mg/l	≤ 10	....

The amount of solids is determined quantitatively by filtering through 1μ- millipore filters of 200 g N_2O_4 Particle distribution on the filter is not determined, but on the other hand the dimension of the largest particles is determined.

10.2 Test 2

N_2O_4 of the following chemical composition is used:

98 wt %	N_2O_4 (Purity c. nominal value of Test 1)
1 wt %	H_2O dest
1 wt.%	Kaltron MDS 113
20 mg/l	(Nitrate mixture: 50 wt. % Fe-Nitrate)
	50 wt. % Ni-Nitrate)

Production of the Mixture. Both impurities (H_2O and Freon) are mixed to the N_2O_4 by weigning. A 20 kg balance is used (1 scale division = 5g).

Work sequence:

- Determination of the empty weight of the HG tank filling container G_B = ... kg
- Filling of the weighed Fe-Ni-Nitrate mixture. Weight according to Item 1 and weighed separately on an analysis balance.
- Fill the amount of water or freon determined according to Point 2 and which has been weighed separately on an analysis balance.
- Add the amount of the distilled N_2O_4 determined according to Point 2.
- Mix the components by shaking the previously closed container.

1. Determination of the FE-Ni-Nitrate amount for 3500 g N_2O_4

Amount of Nitrate $A_N = x \text{ mg/l} \cdot V_{N_2O_4}$

$x = 20$ mg/l

Total amount $N_2O_4 = 3500$ g ($\rho = 1.446$ g/cm^3)

$V_{N_2O_4} = 2.420$ l

For 3500 g N_2O_4 the amount of nitrate is calculated as follows:

$$A_N = 20 \cdot 2{,}42$$

$$A_N = 48{,}4 \text{ mg}$$

The Fe-Ni-Nitrate mixture for 3500 g N_2O_4 consists of 24.2 mg Fe-Nitrate and 24.2 mg Ni-Nitrate.

2. Determination of the weight proportions of water and freon.

Total amount of contaminated N_2O_4 = 3500 g.

Wt. fraction A	=	N_2O_4 dest.
Wt. fraction B	=	H_2O dest.
Wt. fraction C	=	Kaltron MDS 113
A + B + C	=	D

$$A = 0{,}98 \cdot D$$
$$B = 0{,}01 \cdot D$$
$$C = 0{,}01 \cdot D$$

$G_{N_2O_4}$ dest.	=	3430 g ± 5 g *
G_{H_2O} dest.	=	35 g
$G_{Kaltron}$	=	35 g
D	=	3500 g

* ± 5g balance air.

10.3. Test 3

If no blockage occurs for Test 2, in test three the Fe-Ni- Nitrate amount is increased to 40 mg/l.

The contaminated N_2O_4 for this test has the following chemical composition:

98 wt %	N_2O_4	(Purity c. nominal value of Test 1)
1 wt %	H_2O dest.	
1 wt.%	Kaltron MDS 113	
40 mg/l	(Nitrate mixture: 50 wt % Fe-Nitrate 50 wt % Ni-Nitrate)	

Operating sequence just like for the production of the mixture as discussed in Test 2.

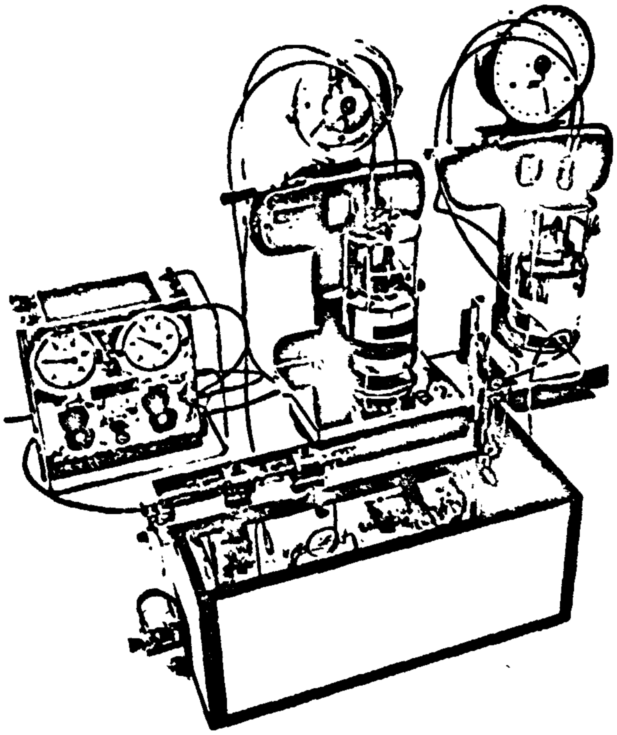
For 3500 g N_2O_4 the amount of nitrate is calculated from

$$A_N = 40 \cdot 2{,}42$$

$$A_N = 96{,}8 \text{ mg}$$

i.e. the nitrate mixture consists of 48.4 mg Fe-Nitrate and 48.4 Ni-Nitrate.

4. Test Configuration



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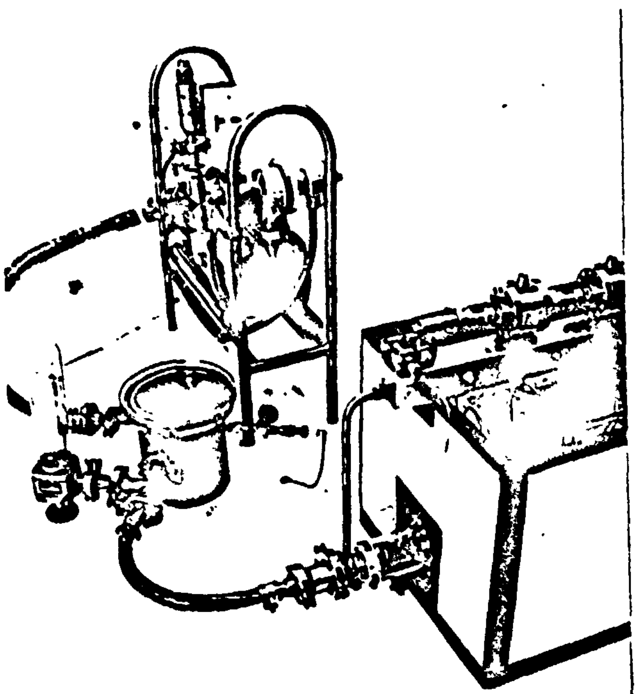

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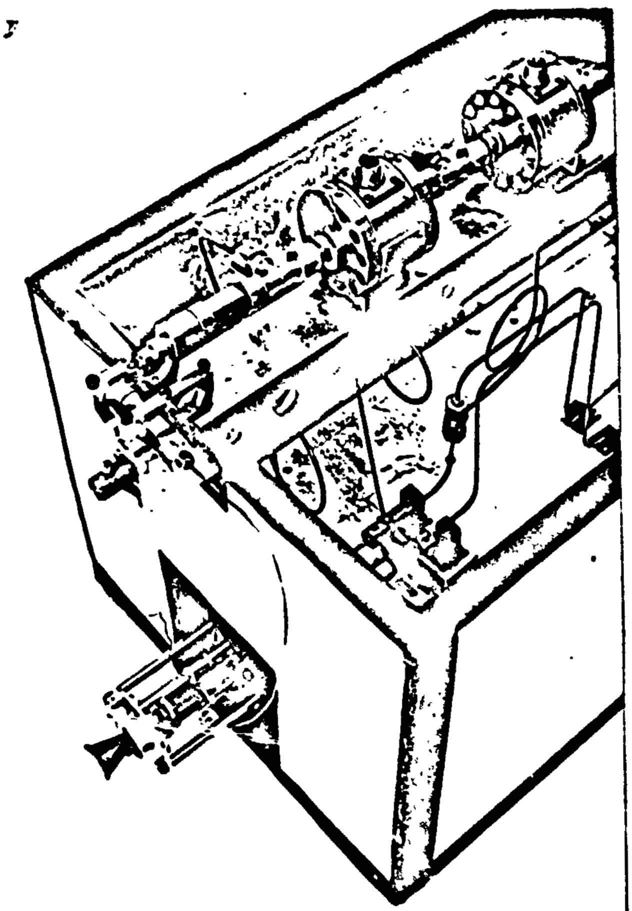
4. Test Configuration



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5. MANUFACTURING DOCUMENTS FOR TEST CONFIGURATION

- Work plan

- Work plan AP - Cleaning of the 10 N-TWK
  Engine SYS 2451 (Unit Nr. 35)
  after the first hot run when investigating
  the HG-anomalie

- Work plan MV2- Anomalie (2nd Test)

- Work plan AP - Cleaning of the 10 N-TWK
  (engine) after the second hot run.

MV-2 Anomalie

Author
Hammerlindl

Date:
12.5.77

Work Plan

1. Documents which apply:

   TN - RT 35 - 7/77
   TN - RT 353- 1/77

2. The points shown in the work plan have to be confirmed by the person performing the test.

3. Work sequence

3.1. Buildup of the test apparatus according to TN - RT 35 - 7/77 Page 5

3.1.1. Equipment to be used or manufactured: Made available and manufactured RT 353 *[signature]*

1. pressure loading device SK 13 380 (BT-Nr. 2)
2 HG-Balances SK 8740 (BT-Nr. 1/2)
1 Vacuum pump type D S6
2 Vacuum hoses with adaptor
2 HG-Containers (N_2O_4) SK 8720 (BT-Nr. 5/7)
2 Arti-return valves Models Nr.2320 R-2 PP-5 (N_2O_4)
Models Nr. 220 T1 - 2PP (MMH)
2 HG-containers (MMH) SK 8730 (BT-Nr. 1/7)
2 HG-container lines (N_2O_4) SK 8692 KK4 - 13
KU5 - 14
(BT-Nr. 2)
1 HG-tank filling lines (N_2O_4) SK 8594 KU5 - N_2
(BT-Nr. 2)
2 HG-container lines (MMH) SK 8693 KU4 - 13
KU5 - 14
(BT-Nr. 2)

MV2 - Anomalie

Author
Hammerlindl
Date:
12.5.77

Work Plan

1 GSP. Drive line (MMH) SK 15470 (BT-Nr. 1)
1 Filter for N_2O_4 SK 2480 - 22
1 Filter for MMH SK 16120
2 HG Pipe lines 1/8" x 0,01" x 1000 lg.
for N_2O_4 and MMH-side
4 manual valves: NUPRO SS - 4H
2 Turbines Model LF 6-00
1 10 N-TWK SYS 2451 BT-Nr. 35
with MBB-Valve SK 4550 BT-Nr. 41
1 TWK-Holder (for engine)
1 Suction device for TWK
2 pressure transducers CEP TYPE 4-351-002
2 pressure transducers CEC TYPE 4-326-L226
2 diaphragms N_2O_4 and MMH Hellmer

3.1.2. Cleaning of all of the equipment mentioned under 3.1.1
Herzberg

Etching and cleaning of all pipelines, connection pieces and welding adaptors Herzberg

3.1.3. Cleanliness Class 1 demonstration
Conveyance System Unit cleanliness better than Class I according to SAE
Pipe 27351 Müller 4. 5.12.77
Hoses
Tanks

3.1.4 Air Tightness of individual components Herzberg

3.1.5 Integration of individual components Herzberg

3.1.6. Air tightness test Herzberg

Author
Hammerlindl

MV2 - Anomalie

Date:
12.5.77

Work Plan

3.1.7. Test Preparation
Mechanic
Measurement

3.1.8. Analyses
MON 0,3
MMH

3.1.9. Hot runs

3.1.10. Materials and Other Materials
Isoprophyl alcohol
Fuel: 15 kg N_2O_4
15 kg MMH

3.1.11. Monitoring during the evacuation

3.1.12. Conveyance system is rinsed with N_2 and is evacuated

3.1.13. Disassembly of individual components

3.1.14. Cleaning of Conveyance System
Hoses
Tanks

3.1.15. TWK (engine)
Disassembly
Cleaning
Assembly
Functional test according to AP-SYS 2451 (35) of 1/25/78.

3.1.16. Evaluation of Results

AP Cleaning of 10 N-TWK
(engine)

Name: SYS 2451 (Unit Nr. 35)
After 1st hot run for investigation of HG-anomalie

Distributor: LA

Author:

Hämmerlindl	RT 353	25.1.78
(Name)	(Abt.)	(Datum)
	RT 353	30.1.78

Investigation of HG-Anomalie

Cleaning 10N-TWK SYS 2451 (35)

CHANGE LIST

Addition/ Change Index	Page Number	Reason for Change	Date	Name/ Division of Engineer	Tested Name/ Division
A	1-4	Building	1/25/78		Hammerlindl

WORK PLAN

Investigating the HG-Anomalie Addition A

Cleaning of 10 N-TWK SYS 2451(35)

1. Engine SYS 2451 is loosened at the separation point between the valve unit SK 4550 and the engine SK 8920. The screw safeties of Positions 13, 14 and 17 are removed by heating to 200-250 °C, using a soldering iron. RT 353

2. Valve unit SK 4550 is installed in spray device SK 11470/1.01. Valve is opened with a constant 24 V and is rinsed with completely salt-free water in the opposite direction according to TN RC 234-43/71

3. Salt-free water is sprayed with 5μ of cleaned N_2.

4. Just like step 2 but using isoprophyl-alcohol.

5. Isopropyl-alcohol is rinsed with 5μ of cleaned nitrogen.

6. SK 8920 is installed on engine and then is equipped with spray device SK 11 340, and is rinsed with completely salt-free water according to TN RC 234-43/71

7. Salt-free water is rinsed with N_2

8. Just like step 6 but using isopropyl-alcohol

9. Isopropyl-alcohol is rinsed with N_2

10. Engine SYS 2451 is assembled according to SYS 2451 Pos. 15 and HV SYS 2451 but without screw safety.

11. Air tightness test using 5μ of purified N_2 in 40/80 gasoline. Test Pressure: 5 bar (Over pressure)

12. Engine is installed in receptacle for hot run anomalie II.

MESSERSCHMITT-BÖLKOW-BLOHM
Gesellschaft mit beschränkter Haftung
Außenstelle Lampoldshausen

Projekt / Auftrag

Nr. RT353
Aussteller [illegible]
Dat. 10.1.72
Blatt 1 von 3

Benennung / Stichwort / Type / Z.-Nr.

WORK PLAN — ANOMALY — second test

Arbeitsfolgeplan MVz-Anomalie (2. Versuch)

Order	1	2	3	4	5	6	7
Abt.							
Name	H. [illegible]						

Pos.	Benennung (approval)	Stck. (no.)	
1	Disassembly & cleaning of conveyance system Demontage u. Reinigung Fördersystem		Zeilinger [illegible]
2	cleaning of hoses Reinigung Schlauchleitungen	4	[illegible]
3	cleaning of tank N_2O_4 Reinigen Tank N_2O_4	1	[illegible]
4	Engine disassembly-removal of valve TWK Demontage, Abbau Ventil Cleaning Reinigung Assembly Montage Funktionsprüfung Functional test	1	[illegible]
5	Fertigung Blendscheibe N_2O_4 mit [illegible]	1	[illegible]

(Illegible)

ORIGINAL PAGE IS OF POOR QUALITY

MESSERSCHMITT-BÖLKOW-BLOHM

Gesellschaft mit beschränkter Haftung

Außenstelle Lampoldshausen

Projekt / Auftrag

Abt. RT353

Aussteller [illegible]

Dat. 10. 9. 71

Blatt 2 [redacted]

Benennung / Stichwort / Type / Z.-Nr.

WORK PLAN ANOMALY

Order	1	2	3	4	5	6	7
Abt.							
Name							

	Pos.	Benennung	lfz.
		approval	no
		(illegible)	
	6	~~Fertigung Filter~~ vorhandenen Filter reinigen u. wiederverwenden!	1
according to the next demonstration for conveyance system, hoses, tank	7	Reinheitsnachweis Fördersystem, Schlauchleitungen, Tank	Güll
air tightness demonstration	8	Dichtigkeitsnachweis	Herberg
vacuum insulation (illegible)	9	Vakuumanlage ~~Ölreiniger~~ verwenden wie vorhanden!	Herberg
Instruction	10	Integration	Herberg
Air tightness test	11	Dichtheitsprüfung	Herberg

MESSERSCHMITT-BÖLKOW-BLOHM
Gesellschaft mit beschränkter Haftung
Außenstelle Lampoldshausen

Aussteller: Hammerlind

Dat. 10. 1. 78

Blatt 3 von 3

Benennung / Stichwort / Type / Z.-Nr.

WORK PLAN ANALY

Order	1	2	3	4	5	6	7
Abt.							
Name							

	Pos.	approval Benennung	no. Stck.	
test preparation (illegible)	12	Versuchsvorbereitung Mechanik Messung		
analysis	13	Analyse N_2O_4 ([illegible]) DFVLR		
Hot run	14	Heißlauf		
materials alcohol fuel	15	Werk- u. Hilfsstoffe Alkohol Treibstoffe 15 kg N_2O_4 15 kg MMH		
monitoring during evacuation	16	Überwachung beim Evakuieren		

AP Cleaning 10 N-TWK (engine)
after second run

SYS 2451 (Unit Nr. 35)
after second hot run when investigating
the HG-anomalie

Distributor: LA

Author:	Hammerlindl	RT 353	25.1.78
	(Name)	(Abt.)	(Datum)
Examine:		RT 353	30.1.78

Investigation of HG- Anomaly
Cleaning 10N-TWK SYS 2451 (35)

CHANGE REGISTER

Version/ Change Index	Page No.	Reason for Change	Date	Author
A	1-4	Manufacturer	1.25.78	Hammerlindl

WORK PLAN Version A

Investigation of HG-Anomalie
Cleaning of 10 N-TWK SYS 2451 (35)

1. Engine SYS 2451 is loosened at the separation point between the valve unit SK 4550 and the engine SK 8920. The screw safeties of Positions 13, 14 and 17 are removed by heating to 200-250°C using a soldering iron. Muckle RT 353

2. Valve unit SK 4550 is installed in spray device SK 11470/1.01. Valve is opened with a constant 24 V and is rinsed with completely salt-free water in the opposite direction according to TN RC 234-43/71 Lu.

3. Salt-free water is sprayed with 5μ of cleaned N_2. Lu.

4. Just like step 2 but using isoprophyl-alcohol. Lu.

5. Isopropyl-alcohol is rinsed with 5μ of cleaned nitrogen. Lu

6. SK 8920 is installed on engine and then is equipped with spray device SK 11 340, and is rinsed with completely salt-free water according to TN RC 234-43/71 Lu.

7. Salt-free water is rinsed with N_2. Lu.

8. Just like step 6 but using isopropyl-alcohol. Lu.

9. Isopropyl-alcohol is rinsed with N_2. Lu.

10. Engine SYS 2451 is assembled according to SYS 2451. Pos. 15 and HV SYS 2451 but without screw safety. Lu.

11. Air tightness test using 5μ of purified N_2 in 40/80 gasoline. Test Pressure: 5 bar (over pressure). Lu.

12. Store engine.

6. TEST INSTRUCTION/ TEST REPORT FOR TEST SERIES 1

TASK DEFINITION

H. Schwerdtfe (2×) H. Hahnberg, H. Hengler,
H. Hundling (1×) Messung, Fr. Keil,
H. Brauer (1×) H. Czaika, (je 1×).

MBB Report:	TN-RT353-5/77	
Author:	H. Czaika	
Division:	RT 354	
Title:	TEST INSTRUCTIONS Ground tests for investigating the MV_2 anomaly	
	First Test Series	Report Size: 21 pages
Date:	12/7/77	Appendix A 1 sheet Appendix B 8 sheet Appendix C 2 sheet

Extended as a test report, test results recorded on 11/1/78.

Author: Division:

1. Study

In order to investigate the MV2 anomaly (TN RT 353-7/77) we carried out hot runs with the 10 N-Engine(under atmospheric conditions).

In this report we specify the required work steps for preparing and executing the hot run tests.

Test 1: Reference test for which no blockage is expected.

Test 2: Hot run test for which N_2O_4 is used with the chemical composition mentioned under Item 2.3.2.2.

Test 3: Is only performed if in test 2 no blockage of the N_2O_4 conveyance system occurs. In this hot run the Fe-Ni-Nitrate fraction in the N_2O_4 is increased.

2. Data on the Test Item and the Test Configuration for the Hot Run.

2.1. Test item:

- 10 N-Engine SYS 2451 Number 35.
  with valve Number 44.

- Original fuel lines (line cross section and length) with filters and diaphragm according to the HG-System H4 (Sketch Page 8) with the conveyance line between the manual valve Ox 4 (BR 4) fuel and the engine.

2.2. Test Configuration:

The test configuration (Sketch Page 8) is built up according to TN RT 35-7/77.

All of the components of the conveyance system and the fuel containers are cleaned according to TN-RT 353-1/77 and cleanliness is demonstrated using the millipore-method (without QS-documentation).

2.3. Fuels and fuel amounts

2.3.1. MMH: (Demonstration not required)

Amount of fuel to be filled: 6300 g

(for an expected testing time of 3 x 24 minutes)

2.3.2. Detailed N_2O_4 with the following chemical composition

2.3.2.1. Hot Run 1

	Nominal Values according to MIL-Spec. 26 539	Actual Values
N_2O_4 wt. %	$\geq$ 99,5	99,34
*H_2O equivalent wt. %	$\leq$ 0,17	0,11
Solids mg/l	$\leq$ 10	

The solid fraction is determined quantitatively by filtering through 1 µm millipore filters of 200 g N_2O_4. Particle distribution on the filter is not determined. (see Test Sequence).

The amount of fuel to be filled: 3500 g

Number of particles, nominal value: Purity better than Class 2 according to SAE. signed RT351 Müller

December 17, 1977

2.3.2.2. Hot Run 2

Distilled N_2O_4 with the following chemical composition:

(see data in TN-RT 353-7/77)

98 wt.% N_2O_4 dest. (Purity see item 2.3.2.1)
1 wt. - % H_2O dest.
1 wt. - % Kaltron MDS 113
20 mg/l Nitrate mixture: 50 wt.% Fe-Nitrate
50 wt.% Ni-Nitrate

*(see preceding page) HNO_3 wt. % 0.64
H_2O free wt. % 0.02
HNO_3 + free H_2O result in an H_2O equivalent of 0.11 wt. %.

Responsible for item 2.3.2.2. - RT351 - Mrs. Keil 22

Total amount of contaminated N_2O_4 : 3500 g (± 5 g balance air)

N_2O_4 dest.	=	3430 g
H_2O dest.	=	35 g
Kaltron 113 MDS	=	35 g
Fe-Nitrate	=	24,2 mg
Ni-Nitrate	=	24,2 mg

2.3.2.3. Hot run 3 (is performed because no blockage occurred in Hot run 2)

Distilled N_2O_4 with chemical composition shown under Item 2.3.2.2., but the Fe-Ni-Nitrate is increased to 40 mg/l .

For 3500 g N_2O_4 we find

Fe-Nitrate: 48.4 mg
Ni-Nitrate: 48.4 mg

2.3.3. Filling of the N_2O_4 and the MMH containers

2.3.3.1. MMH-Container:

MMH is filled through a $1\mu m$ Millipore filter and filling is controlled by weighing. Ventilation opening on the container is first opened, if over-pressure exists in the container, in order to avoid penetration of air.

2.3.3.2. Filling of N_2O_4 Container

Filling of distilled N_2O_4 using 1µm Millipore filters, where filling is controlled by weighing. Ventilation of the container is only opened if over-pressure already exists in the container, in order to avoid penetration of air. When producing the mixture for Test 2 and Test 3, the impurities (H_2O and freon) are mixed by weighing (2µm filter). A 10 kg balance is used (1 scale division = 5 g).

Sequence:

- Determination of the empty weight of the N_2O_4 container (residual N_2O_4 is emptied out) GB = kg
- Filling of the Fe-Ni-Nitrate mixture which was weighed separately on an analysis balance.
- Filling of Kaltron 113 MDS or the amount of water which has been weighed separately on an analysis balance.
- Weighing of the distilled N_2O_4
- Mixing of components by shaking the closed container.
- Before filling the N_2O_4 into the container for hot run 3, the container is cleaned according to TN-RT 353-1/77 .

2.4. Measurement point plan

Measurement point	Range	Recording*	Remarks
$\Delta p1$ (Fi)	0 - 6 at	V, D, A	ged. 100 μF
$\Delta p2$ (Bl)	0 - 6 at	V, D, A	ged. 100 μF
P_L	0 - 20 bar	V, D, A	ged. 100 μF
P_c	0 - 9 bar	V, D, A	ged. 100 μF
$\dot{m}_O$	Hz	D, A	
$\dot{m}_B$	Hz	D, A	
Valve signal Engine		V	
Time		D, A	
Pressure mark		V	

* V = Visicorder; D = pressure; A = Reading

Pressure measurement transducers $\Delta p1$ CEC TYP 4 - 351 - 002

$\Delta p2$ CEC TYP 4 - 351 - 002

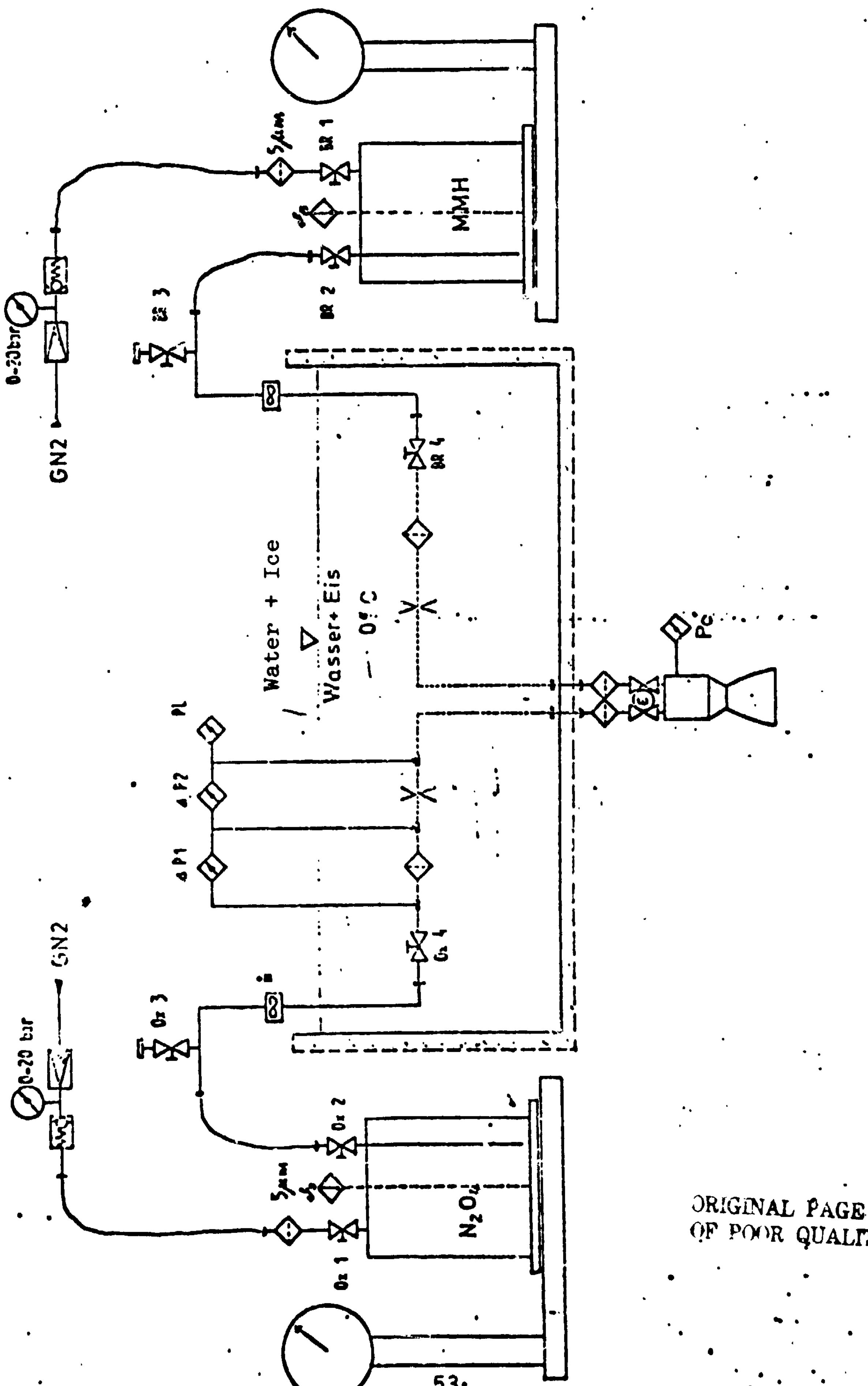
P_L, P_c CEC 4 - 326 - L 226

Turbine flow meter

COX 6-00 N_2O_4 Turb.Nr. 7191

COX 6-00 MMH Turb.Nr. 15732

Calibration of pressure transducers using 2 μ Filter (nom)


MMH
GN2
0-20bar
Water + Ice
Wasser+ Eis
0°C
Pc
GN2
0-20 bar
N_2O_4

3. Test Sequence

3.1. Preparations

- filling of fuels (Point 2.3.3)
- calibration and installation of transducers
- functional test of engine valve
- air tightness test for the entire conveyance system by connecting through HV-OX3 (BR3) using GN2 = 10 bar (Filter 2µm)
- Filling of the pan with ice water
- pressurization of the N_2O_4 container at P_T (HV-OX2 "closed")

Pressure balance:

$P_{E\ N_2O_4}$	= 13,30	bar
Δ p Blende	= 5,0	bar
Δ p FÖS	= 0,5	bar
	18,80	bar
P_T*	17,80	atg

- * for hot run 2 + 3 adjust values from hot run 1.
- Evacuation of the N_2O_4 conveyance system using HV-OX3 ($\leq$ 1 Torr) HV-OX4 "On"
- Filling of the N_2O_4 conveyance system by opening of the hand valve Ox 2
- Removal of a cleanliness sample with Millipore adaptor with a 1µm filter and a flux of 200 g at the hand valve Ox 3.
- Qualitative check of the filter for particle amount, particle size and particle identification.
- pressurization of the MMH-container with PT (HV-BR 2"Closed")

Pressure balance $P_{E\ MMH}$ - 14,10 bar

Δp diaphragm - 4,5 bar

Δp FÖS - 0,3 bar

18,9 bar

P_T* 17,9 atg

(* For hot run 2 + 3 adjust values from hot run 1)

- evacuation of the MMH-conveyance system through HV-BR 3 ($\leq$ 1 Torr) HV-BR 4 "Open"
- Filling of the MMH-conveyance system by opening hand valve BR 2.

3.2. Nominal operating conditions for engine

$\dot{m}_{ges}$	=	3,54	g/s	3,54		
r	=	1,64	g/s			
$\dot{m}_{N_2O_4}$	=	2,20	g/s	2,11	(Turb.Nr.	7191)
$\dot{m}_{MMH}$	=	1,34	g/s	1,14	(Turb.Nr.	15732)
P_{E-O}	=	13,3	bar			
P_{E-3}	=	14,1	bar			
P_c	=	8,7	bar			

3.3. Hot run 1 (reference test for which no blockage is expected)
Test No. 02-2550/1 on December 16, 1977.

3.3.1. Manual Recording:

			Nominal value	
Temperatures in the tank	$\vartheta_{N_2O_4}$	:	12	°C
	ϑ_{MMH}	:	9	°C
	ϑ_{H_2O}	:	2	°C

Ice water temperature	N_2O_4	:	18,717	kg
Balance reading	MMH	:	13,780	kg
Tank pressurization adjustment values	N_2O_4	:	17,8	atg
	MMH	:	17,95	atg

- Equalization of differential pressure transducers

- Check hand valves

Ox 1 / BR 1	"on"
Ox 2 / BR 2	"on"
Ox 3 / BR 3	"off"
Ox 4 / BR 4	"on"

3.3.2. Ignition of Engines

- 2 seconds before Ignition, turn on engine Visicorder 1 cm/s
- upon ignition start engine time and print out in time intervals of 2 minutes (2x)
- check the mass throughputs: if necessary interrupt engine operation (stop the time), if deviations in $\dot{m}_{ges}$ nom and r nom are found. Throughput correction by changing the tank pressures.
- Observation of differential pressures.
- Observation of temperature load on engine, especially on the vacuum nozzle.
  Discontinue test for critical operating state.

3.3.3. Engine shut down at test time

t_{ges} = 1440 s Nominal time = 1400 S

- Visicorder "Off"

- **Manual Recording:**

		Nominal value	
Engine temperature in the tank	$\vartheta_{N_2O_4}$	10	°C
	ϑ_{MMH}	10	°C
Ice Water	ϑ_{H_2O}	1,9	°C
Balance Reading	N_2O_4	7,760	kg
	MMH	11,780	kg
Tank pressurization setting	N_2O_4	17,80	atg
	MMH	17,95	atg.

- Reduction of P_{T-O} and P_{T-B}
- Close hand valves OX 2 and BR 2
  OX 4 and BR 4
- Empty N_2O_4 container

3.4. Hot Run 2 (Test with contaminated N_2O_4 according to Item 2.3.2.2.)
Test Number 02-2950/2
December 16, 1977

3.4.1. **Manual Recording:**

		Nominal value	
Engine temperature in the tank	$\vartheta_{N_2O_4}$:	12	°C
	ϑ_{MMH}:	10	°C
Ice water	ϑ_{H_2O}:	0,6	°C
Balance reading	N_2O_4:	10,98	kg
	MMH :	11,78	kg
Adjusted tank pressurization	N_2O_4:	17,8	atg
(see adjusted values for Hot Run 1)	MMH :	17,95	atg

- Equalization of differential pressure measurement transducers

Check hand valves	Ox 1 / BR 1	"on"
	Ox 2 / BR 2	"on"
	Ox 3 / BR 3	"off"
	Ox 4 / BR 4	"on"

3.4.2. Engine ignition

- 2 seconds for ignition turn-on visicorder 1 cm/s
- upon engine ignition start time and print out values in intervals of 1 minute (2x). Shorten intervals for throughput changes.
- Observe temperature load-on engine, especially on vacuum nozzle. Discontinue test for critical operating condition.
- Observe differential pressure, injection pressures and flux readings in order to evaluate possible throughput changes and whether these cause the beginning of blockage.
- Let blockages which can occur in the N_2O_4- conveyance system increase as long as the operating state of the engine is not critical because of the displacement of the mixture ratio.

3.4.3. Engine shut-down

3.4.3.1. After blockage of the N_2O_4 conveyance system has occurred

Nominal value:

$\dot{m}_{N_2O_4}$ 0,44 g/s $\hat{=}$ Imp/s

(accordingly 20 % $\cdot$ $\dot{m}_{N_2O_4}$ Nom.)

3.4.3.2. After an operating time of

$$t = 1440 \text{ s}$$

- Visicorder "OFF"

Recording:

		Nominal value	
Engine Temperature in the tank	$\vartheta_{N_2O_4}$:	10	°C
Ice water temperature	ϑ_{MMH}:	8	°C
	ϑ_{H_2O}:	1	°C
Balance reading	N_2O_4:	10,342	
	MMH :	11,135	
Pressurization adjusted values	N_2O_4:	17,8	atg
	MMH :	17,95	atg
Test time	t :	420	

- Reduction in P_{TO} and P_{TB}
- Close hand valves Ox 2 and BR 2
  Ox 4 and BR 4
- If blockage occurs during the hot run: further sequence according to Item 3.4.4.
- If no blockage has occurred during the hot run, further sequence according to Item 3.5.

3.4.4. Blockage in the N_2O_4- conveyance system:

- From the changes in the differential pressures or injection pressure, determine the blockage location (filter, diaphragm, injection system).
- Rinse the MMH-conveyance system with N_2 with an open engine valve using the hand valve BR 3 (observe BR fuel flux reading).
- Remove much of the fuels from the engine and the conveyance system (hand valves Ox 4 and BR 4 in the conveyance system are closed) by connecting a gas jet pump through an adapter

to the vacuum nozzle of the engine (valve open).

- after this, connect the vacuum pump to the adapter

- open the engine valve and evacuate the conveyance system over 48 hours

  $p_v \leq 10^{-2}$ Torr

- temperature on the valve of the engine should be checked. At the beginning, make recordings at time intervals of ten minutes.
  - if 95°C is exceeded close the engine valve and open it again after the temperature as dropped and then record P_v
  - after the end of the evacuation time close the engine valve and close off the adapter in the vacuum pump.

3.4.4.1. Repetition of the hot run test 2 Test No. 02-2550/3
December 19, 1977

- Pressurization of N_2O_4 and MMH container. Adjustment values as under item 3.4.1.

- Evacuation of the N_2O_4 or MMH-conveyance system (hand valves in the conveyance system HV-Ox 4 and HV-BR 4 are closed) through HV-Ox 3/BR 3

- fold the N_2O_4 conveyance system:
  Handvalve in the tank HV-Ox 2 "OPEN"
  Handvalve in the conveyance system HV-Ox 4 "OPEN"

- fill the MMH-conveyance system:
  Handvalve in the tank HV-BR 2 "OPEN"
  Handvalve in the conveyance system HV-BR 4 "OPEN"

- Manual Recording

		Nominal value	
Fuel temperature in the tank	$\vartheta_{N_2O_4}$:	9	°C
	ϑ_{MMH} :	8	°C
Ice water	$\vartheta_{H_2O_4}$:	3	°C
Balance reading	N_2O_4:	10,185	kg
	MMH :	11,090	kg
Adjustment values for tank pressurization (see adjustment values of 3.4.1.).	N_2O_4:	17,8	atg
	MMH :	17,95	atg

- Equalization of differential pressure transducers
- Check hand valves Ox 1 / BR 1 "OPEN"
  Ox 2 / BR 2 "OPEN"
  Ox 3 / BR 3 "CLOSED"
  Ox 4 / BR 4 "OPEN"

3.4.4.2. Ignition of Engine

- 2 seconds before engine ignition-Visicorder "ON" = 1 cm/s

- at engine ignition start time counting and print out values at 1 minute intervals (2x). Shorten time intervals if there are throughput changes.

- Observe the following: Temperature load on the engine, especially on the vacuum nozzle. Stop test for critical operating test.

- Observe differential pressures, injection pressures and flux readings in order to evaluate througnput changes which could occur, whether these are caused by a beginning blockage.

- allow (occurring) blockages) in the N_2O_4-conveyance system to increase as long as the operating state of the engine is not critical because of displacement of the mixing ratio.

3.4.4.3. Engine Shutdown

3.4.4.3.1. - When the N_2O_4 conveyance system is blocked (same blockage as before evacuation)

3.4.4.3.2. - After an operating time corresponding to corresponding to the available N_2O_4

(Filled in N_2O_4 minus consumed N_2O_4 for the hot run 2 = remaining amount for repetition).

- Visicorder "OFF"

- Recording:

			Nominal value	
Fuel temperature	$\vartheta_{N_2O_4}$	:	9	°C
	ϑ_{MMH}	:	8	°C
Ice water	ϑ_{H_2O}	:	3	°C
Balance reading	N_2O_4	:	9,450	kg
	MMH	:	10,380	kg
Tank pressurization adjustment value	N_2O_4	:	17,8	atg
	MMH	:	17,95	atg
Test time	t	:	445	s

- Reduce P_{TO} and P_{TB}

- Close handvalves Ox 2 and BR 2
  Ox 4 and BR 4

- If the blockages are successfully removed, empty Ox and BR fuel conveyance systems.

- In the case of a failure, rinse MMH conveyance with GN 2 (2μm Filter) . N_2O_4 Conveyance system is rinsed with a 2μm filter using distilled water at about 60°C. The rinsing water is captured in a clean container.

3.5. Hot Run 3 (Test with contaminated N_2O_4 according to Item 2.3.2.3.)

This hot run is carried out if no blockage has occurred during hot run 2. Hot run sequence is the same as for hot run 2 (item 3.4.1.).

[illegible]

Benennung/Stichwort/Type/Z.-Nr.	Dat. 12.11.'77
Tuning Diaphragm Specifications Vorgaben Abstimmblenden	~~Page~~ Blatt 1 von 1
	JJ Nr 163

Order	1	2	3	4	5	6	7
Abt.							
Name	H. Braun						

z.K. H. Herzberg

Regarding ground test for investigating MV2 anomaly according to TN-RT-7/77.

Betr. Bodentests zur Untersuchung der MV2-Anomalien gemäß TN-RT 35-7/77

Abstimmblenden.

Tuning Diaphragms

according to TN RC 31 -65/44 (Tuning (Illegible))

Gemäß TN RC 31-65/44 (Abstimmung [illegible] MV2)

we find the following flux values for the diaphragms

ergeben sich folgende Flußzahlen für die Blenden:

$$TN_{Bl_{Ox}} = 0{,}0579 \text{ mm}^2$$

$$TN_{Bl_{Br}} = 0{,}0493 \text{ mm}^2$$

ORIGINAL PAGE IS OF POOR QUALITY

Definition: $TN = \frac{\dot{m}}{14{,}142\sqrt{\rho \cdot \Delta p}}$ mm^2

$\dot{m}$: g/s; ρ: g/cm³; Δp: bar

oder

$$\Delta p = \left(\frac{\dot{m}}{TN}\right)^2 \cdot \frac{1}{200 \cdot \rho} \quad \text{bar}$$

Nominaldurchsätze: $F = 10\ N$

Nominal throughputs: $I_{sp} = 2825\ \frac{Ns}{kg}$ $\quad \varepsilon = 1{,}645$

$$\dot{m}_{ges} = \frac{10}{2825} = 0{,}00354\ \text{kg/s}$$

$$= 3{,}54\ \text{g/s}$$

Specifications

Vorgaben

[illegible]

(illegible)

MMH [illegible] $\dot{m}_{Br} = \frac{\dot{m}_{ges}}{\varepsilon + 1} = \frac{3{,}54}{2{,}645} = \underline{\underline{1{,}34\ \text{g/s}}}$ $\quad$ 1,7[illegible]

N_2O_4 [illegible] $\dot{m}_{Ox} = \varepsilon \cdot \dot{m}_{Br} = \underline{\underline{2{,}20\ \text{g/s}}}$ $\quad$ 2,0[illegible]

[illegible] $\Delta p_{Br} = \left(\frac{1{,}34}{0{,}0493}\right)^2 \cdot \frac{1}{200 \cdot 0{,}879} = \underline{\underline{4{,}2}}$ bar $\approx 4{,}3 \frac{1}{c}$

$\Delta p_{Ox} = \left(\frac{2{,}20}{0{,}0579}\right)^2 \cdot \frac{1}{200 \cdot 1{,}446} = \underline{\underline{5}}$ bar $\approx 5{,}1 \frac{1}{c}$

Gesellschaft mit beschränkter Haftung
Außenstelle Lampoldshausen

TN-RT353-5/77

Hamberg

Benennung / Stichwort / Type / Z.-Nr.

Q S - N A C H W E I S

QS Demonstration

Page 1 von 8

for:
für: Grund test for investigating the MV2 anomaly

Order	1	2	3	4	5	6	7
Abt.							
Name							

name: HG N_2O_4 container
Benennung: HG - N_2O_4 Behälter

Item No:
Sach-Nr.: 8720

Component No:
Bautl.-Nr.: 7.

Fabrication No.
Fabr.-Nr.:

To:
Rohr:

Nominal value for cleanliness demonstration: Class
Soll für Reinheitsnachweis: Klasse .... nach SAE

Ist: [illegible] SAE RT351 [illegible] 28.11.77
according to SAE
Actual value greater than (illegible) SAE

Soll für Betriebsdrucknachweis:
Nominal value for operating pressure demonstration:
Ist:
Actual

Soll für Dichtheitsnachweis: Nominal for air tightness demonstration:

Ist: 25 bar RT351 [illegible] 28.11.77
Nominal:

Medien für Reinheitsnachweis: Isoproponol
Media for cleanliness demonstration: Isoproponol

Medien für Betriebsdrucknachweis:
Media for operating pressure demonstration

Medien für Dichtheitsnachweis: N2. Netz. [illegible]
Media for air tightness demonstration: line N_2

Chemische Reinheit mit Drägerröhrchen .... geprüft

Ist: Restmengen von .... ppm

Chemical purity with tubes....... tested
Nominal: Residual amounts of... ppm

Die mit "QS" versehenen Sollwerte sind von der QS nachzuweisen.
The nominal values with "QS" have to be demonstrated by the QS.

-Munding- -Braun-

Außenstelle Lampoldshausen | | Herzberg

Benennung / Stichwort / Typ / Z.-Nr. QS DEMONSTRATION QS - NACHWEIS | Dat. 24.11.1977

| | Page Blatt 2 von 8

FOR: für: *Bodentests zur Untersuchung der MV2-Anomalie*
Ground tests for investigating the MV_2 anomalie

Order	1	2	3	4	5	6	7
Abt.							
Name							

Name: HG MMH container
Benennung: *HG-MMH-Behälter-2*

Item No.
Sach-Nr.: *8730*

Component No.
Bautl.-Nr.: *1.*

Fabrication No.
Fabr.-Nr.:

To:
Rohr:

Nominal value for cleanliness demonstration: Class
Soll für Reinheitsnachweis: Klasse .... nach SAE

IST: *besser Kl. 1 nach SAE 24.11.77 [illegible]*
according to SAE
Actual value greater than (illegible) SAE

Soll für Betriebsdrucknachweis:
Nominal value for operating pressure demonstration:
IST:
Actual:

Soll für Dichtheitsnachweis: Nominal for air tightness demonstration:
IST: *25 bar* *RT354 [illegible]* *26.11.77*
Nominal:

Medien für Reinheitsnachweis: *Isopropanol (ipa.)*
Media for cleanliness demonstration: Isoproponol

Medien für Betriebsdrucknachweis:
Media for operating pressure demonstration:

Medien für Dichtheitsnachweis: *N2, Netz, Lm.*
Media for air tightness demonstration: line N_2

Chemische Reinheit mit Drägerröhrchen .... geprüft
Chemical purity with tubes.....tested
Ist: Restmengen von
Nominal: Residual amounts of:............ .... ppm

Die mit QS versehenen Sollwerte sind von der QS nachzuweisen. The nominal values with "QS" have to be demonstrated by the QS.

-Munding- -Braun-

Benennung / Stichwort / Typ / Z.-Nr.

QS - DEMONSTRATION
Q S - N A C H W E I S

Dat. 28.11.1977
Page
Blatt 3 von 8

for: Ground tests for investigating the MV_2 anomaly
für: Bodentests zur Untersuchung der MV2-Anomalie..

Order	1		2		3		4		5		6		7
...													
Name													

Name: N_2O_4 HG container, lines
Benennung: N2O4 - HG - Behälterleitungen

Item No.
Sach-Nr.: 8692 Ku 4 - 13

Component No. Ku 5 - 14
Bautl.-Nr.: 2.

Fabrication No.
Fabr.-Nr.:

To:
Rohr:

Nominal value for cleanliness demonstration: Class
Soll für Reinheitsnachweis: Klasse .... nach SAE according to SAE

Ist: feinheit besser Kl. 1 nach SAE RT3T4 [illegible] 28.11.77
Actual value greater than (illegible) SAE
better than Class 1 according to SAE 11/28/77

Soll für Betriebsdrucknachweis: 25 bar
Nominal for operating pressure demonstration:
Ist:

Nominal:
Nominal for air tightness demonstration
Soll für Dichtheitsnachweis: 40 bar

Ist: 40 bar RT354 [illegible] 28.11.77
Nominal

Medien für Reinheitsnachweis: Isopropanol
Media for cleanliness demonstration: Isoproponol

Medien für Betriebsdrucknachweis:
Media for operating pressure demonstration:

Medien für Dichtheitsnachweis: N2, Netz, Lam.
Media for air tightness demonstration: line N_2

Chemische Reinheit mit Drägerröhrchen ....geprüf
Chemical purity with tubes..... tested
Ist: Restmengen von .... ppm
Nominal: residual amounts of... ppm

Die mit "QS" versehenen Sollwerte sind von der QS nachzuweisen. The nominal values with "QS" have to be demonstrated by the QS.

-Munding- -Braun-

for: Ground testsQS DEMONSTRATION

für: Bodentests zur Untersuchung der MV-Anomalie.

• For investigating the MV anomaly

Page Blatt 4 von 8

Order	1	2	3	4	5	6	7
Abt.							
Name							

Name:
Benennung: N_2O_4 HG Betankungsleitung

N_2O_4 HG tank filling line

Item No.
Sach-Nr.: 8194 Ku 6 - N2.
Component No.

Bautl.-Nr.: 2.

Fabrication No.
Fabr.-Nr.:

To:
Rohr:

Nominal value for cleanliness demonstration: Cleanliness

Soll für Reinheitsnachweis: Klasse .... according to SAE nach SAE

Ist: besser kl. 1 nach SAE RT351 [illegible] 28.11.77

better than class 1 according to SAE

Soll für Betriebsdrucknachweis: 25 bar

Nominal for operating pressure demonstration:

Ist:

Actual

Soll für Dichtheitsnachweis: 40 bar Nominal for air tightness test

Ist: 40 bar RT351 [illegible] 28.11.77

Actual

Medien für Reinheitsnachweis: N2 Netz Lam

Media for cleanliness demonstration: line N_2

Medien für Betriebsdrucknachweis:

Media for operating pressure demonstration:

Medien für Dichtheitsnachweis: N2 Netz. Lam.

Media for air tightness demonstration line N_2

Chemische Reinheit mit Drägerröhrchen .... geprüft

Chemical purity with tube ... tested

Ist: Restmengen von ... . ppm.

Nominal: Residual amounts of

Die mit "QS" versehenen Sollwerte sind von der QS nachzuweisen. The nominal values with "QS" have to be demonstrated by the QS.

-Munding- -Braun-

Gesellschaft mit beschränkter Haftung
Außenstelle Lampoldshausen

Anhang B zu
TN-RT353-5/77

Aussteller: Herzberg

Benennung / Stichwort / Type / Z.-Nr.

Dat. 24.11.1977

Blatt 6 von 8

Page

QS - NACHWEIS
QS DEMONSTRATION

für: Bodentests zur Untersuchung der MV₂-Anomalie
for ground tests for investigating the MV₂ anomaly

Order	1	2	3	4	5	6	7
Abt.							
Name							

Name: MMH-Hg container lines
Benennung: MMH-HG-Behälter Leitungen

Item No.
Sach-Nr.: 8693 Ku 4 - 13
Component No. Ku 5 - 14
Bautl.-Nr.: 2.
Fabrication No.
Fabr.-Nr.:

To:
Rohr:

Nominal value for cleanliness demonstration: Class .... according to SAE
Soll für Reinheitsnachweis: Klasse .... nach SAE

Ist: besser Kl. 1 nach SAE Müller W. 24.11.77
Actual: better than class 1 according to SAE

Soll für Betriebsdrucknachweis: 25 bar
Nominal value for operating pressure demonstration:
Ist:
Actual

Soll für Dichtheitsnachweis: 40 bar Nominal value for air tightness demonstration

Ist: 40 bar RT351 Müller W. 29.11.77

Nominal:

Medien für Reinheitsnachweis: isopropanol (ipa)
Media for cleanliness demonstration

Medien für Betriebsdrucknachweis:
Media for operating pressure demonstration

Medien für Dichtheitsnachweis: N_2 Netz Lam.
Media for air tightness demonstration: line N_2

Die mit "QS" versehenen Sollwerte sind von der QS nachzuweisen. The nominal values with "QS" have to be demonstrated by the QS.

Chemische Reinheit mit Drägerröhrchen .... geprüft.
Chemical purity with tubes....tested

Ist: Restmengen von
Nominal: Residual amounts of .... ppm

-Nunding- -Braun-

Benennung / Stichwort / Type / Z.-Nr.

QS - NACHWEIS

for:
für: QS DEMONSTRATION PAGE

Dat.: 2? 11 1977

Blatt 6 von 8

Order	1		2		3		4		5		6		7
Abt.													
Name													

Name: GSP Drive line Apog for MMH pressurization
Benennung: GSP - Antriebsleitung Apog für MMH Bedrückung

Item No.
Sach-Nr.: 15470

Component No:
Bautl.-Nr.: 1.

Fabrication No:
Fabr.-Nr.:

To:
Rohr:

Nominal value for cleanliness demonstration: Class .... according to SAE
Soll für Reinheitsnachweis: Klasse .... nach SAE

Ist: besser Kl. 1 nach SAE RT351 Müller 28.11.77
Actual: better than class 1 according to SAE

Soll für Betriebsdrucknachweis: 25 bar
Nominal value for operating pressure demonstration
Ist:

Actual:

Soll für Dichtheitsnachweis: 40 bar
Nominal for air tightness demonsration

Ist: 40 bar RT351 Müller 28.11.77
Actual

Medien für Reinheitsnachweis: N_2 Netz. Lsm.
Media for cleanliness demonstration: Line N_2

Medien für Betriebsdrucknachweis:
Media for operating pressure demonstration:

Medien für Dichtheitsnachweis: N_2 Netz Lsm
Media for air tightness demonstration line N_2

Chemische Reinheit mit Drägerröhrchen .... geprüf
Chemical purity with tubes....tested
Ist: Restmengen von
Nominal: Residual ~~amounts of~~: .... ppm

Die mit "QS" versehenen Sollwerte sind von der QS nachzuweisen. The nominal values with "QS" have to be demonstrated by the QS.

-Nunding- -Braun-

Außenstelle Lampoldshausen	TN-RT353-5/77	Autor: Hirzberg
Benennung/Stichwort/Typ/Z.-Nr. for für: Bauteile zur Untersuchung der MPL-Anwendung	QS - NACHWEIS QS DEMONSTRATION	Dat.: Page Blatt 7 von 8

Order	1	2	3	4	5	6	7
Abt.							
Name							

Name: Test design on N_2O_4 side
Benennung: Testaufbau N_2O_4 Seite

Item No.
Sach-Nr.:
Component No:

Bautl.-Nr.:

Fabrication No.;
Fabr.-Nr.:

Filter MQ SK2480-23 BT, Gehäuse Nr. 20/21
Housing

Rohr: HG Rohr 1/8" x 0,01" x 1000 mm lang
To:
Turbine: Modell LF 6C? Serial Nr 7491
Handventile: Nupro - SS -4H.
Handvalve

Soll für Reinheitsnachweis: Klasse .... nach SAE
Nominal value for cleanliness demonstration according to SAE

Ist: besser Kl. 1 nach SAE RT351 Messung 1.12.77
Actual: better than Class 1 according to SAE

Soll für Betriebsdrucknachweis:
Nominal value for operating pressure demonstration
Ist:

Actual

Soll für Dichtheitsnachweis:

Nominal for air tightness demonstration
Ist:
Actual

Medien für Reinheitsnachweis: Isopropanol

Media for cleanliness demonstration:

Medien für Betriebsdrucknachweis:

Media for operating pressure demonstration:

Medien für Dichtheitsnachweis: N_2 Netz - Lsm.

Media for air tightness demonstation: Line N_2

Chemische Reinheit mit Drägerröhrchen
Chemical purity with tubes....tested ....geprüft
Ist: Restmengen von .... ppm

Nominal: Residual amounts of

Die mit "QS" versehenen Sollwerte sind von der QS nachzuweisen. The nominal values with "QS" have to be demonstrated by the QS.

-Munding- -Braun-

Benennung / Stichwort / Type / Z.-Nr.

QS - NACHWEIS

QS DEMONSTRATION

Page

Dat. 31.11.77

Blatt 8 von 8

für: Bodentests zur Untersuchung der MV_2-Anomalie

for: Ground tests for investigating the MV_2 anomaly

Order	1	2	3	4	5	6	7
Abt.							
Name							

Name: **Test configuration on MMH side**
Benennung: Testaufbau MMH Seite

Item No:
Sach-Nr.:

Component Nr.
Bautl.-Nr.:

Fabrication Nr.
Fabr.-Nr.:

To:
Rohr: HG Rohr 1/8" x 0,04" x 1000 mm lang
tube
Turbine: Model LF 6-00 Serial Nr 15732
Handventile: Nupro SS-4H.
handvalve

Nominal value for cleanliness demonstration
Soll für Reinheitsnachweis: Klasse .... nach SAE
Class according to SAE

Ist: besser Kl 1 nach SAE RT354 [illegible] 1.12.77
Actual: better than Class 1 according to SAE

Soll für Betriebsdrucknachweis:
Nominal value for operating pressure demonstration:
Ist:

Actual:

Soll für Dichtheitsnachweis:

Nominal for air tightness demonstration:
Ist:

Nominal:

Medien für Reinheitsnachweis: Isopropanol
Media for cleanliness demonstration:

Medien für Betriebsdrucknachweis:
Media for operating pressure demonstration:

Medien für Dichtheitsnachweis: N_2 Netz-Lm.
Media for air tightness demonstration: line N_2

Chemische Reinheit mit Drägerröhrchen .... geprüft
Chemical purity with tubes .... tested.
Ist: Restmengen von
Nominal Residual amounts of................ .... ppm

Die mit "QS" versehenen Sollwerte sind von der QS nachzuweisen. The nominal values with "QS" have to be demonstrated by the QS.

-Munding- -Braun-

Gesellschaft mit beschränkter Haftung Außenstelle Lampoldshausen	TN-RT353-5/77 Appendix C to	Aussteller Braun
Benennung / Stichwort / Type / Z.-Nr. Evacuation Evakuieren / Pos. 3.4.4 TN RT 353-5/77 MV2 - Anomalie Anomaly		Dat. 16.12.77 Blatt 1 von 2 Bl.30

Order	1	2	3	4	5	6	7
Abt.							
Name							

The temperature on the engine is measured using a measurement bridge through the resistance of the coil.

Die Temperatur am Triebwerk wird mit einer Meßbrücke über den Widerstand der Spule gemessen.

$$R_{max} = 331 \text{ Ohm} \hat{=} 95^{\circ}C$$

Temperatur an der Ox-Blende, Soll 28°C
Temperature on the OX-diaphragm Nominal 28°C
Betriebsspannung für Triebwerk 27 Volt DC

operating voltage for Engine 27 Volts DC

Monitoring Überwachung Time Dat.	Uhrzeit	Resistance of coil Widerst. der Spule [Ohm]	Temperature at OX diaphragm Temp. an Ox-Blende [°C]	Vakuum Vacuum [Torr]	Remarks Bemerkungen	Name
16.12.	15 30	251	15°C	Umgebungsdruck	Beginn der Evakuierung Beginning of evacuation	Herzberg
"	15 45	295	18°C	4x10⁻²		Braun/Herz.
"	16 00	—	18°C	10⁻¹	Evacuation interrupted Evakuierung unterbrochen, Sauglleitung vom Tbk zum Recipient mit brauner Flüssigkeit stark verschmutzt! Suction line contaminated from engine to recipient with a brown liquid	Leitung gereinigt erneut evakuiert
"	16 50	254	24°C	0,7	Engine valve closed Tbk-Ventil geschlossen	[illegible]
"	17 00	254	24°C	6x10⁻²	Engine valve open Tbk-Ventil geöffnet	[illegible]
"	18 15	300	27.5°C	3x10⁻²	"	
"	21 30	300	27,5°C	3x10⁻³		[illegible]
17.12.	8 15	296	26 °C	4x10⁻³	Heating (light bulb) 4 cm closer Heizung (Glühlampe) 4 cm näher Coil similar element measured Spule mit Thermofühler 23°C	Thermofühler 23°C 73

Gesellschaft mit beschränkter Haftung Außenstelle Lampoldshausen	...nn ng C TN-RT353-5/77 Appendix C to	Aussteller Braun

Benennung/Stichwort/Type/Z.-Nr.

Evacuation:
Evakuieren / Pos. 3.4.4 TN RT 353-5/77

MV2 - Anomalie Anomaly

Dat. 16.12.77

Page Blatt 2 von 2

Bl. 31

Order	1	2	3	4	5	6	7
Abt.							
Name							

Monitoring Überwachung Dat. Time	Uhrzeit	Resistance Widerst. d.Spule coil [Ohm]	Temp. at OX diaphragm Temp.an Ox-Blende [°C]	Vacuum Vakuum [Torr]	Remarks Bemerkungen	Name
17.12	10^{10}	300	26.7	5×10^{-3}		[illegible]
"	12^{00}	300	28.1	4×10^{-3}		[illegible]
17.12.	16^{10}	300	26.0/27.5	4×10^{-3}	26.° Thermofühler	[illegible]
17.12	20^{11}	300	24 / 28.5	4×10^{-3}	24 " Thermoelements	[illegible]
18.12	$5^{??}$	296	22 / 26.5	4×10^{-3}	22 "	[illegible]
(Glühlampe 5 cm näher zur Blende)						
18.12.	11^{00}	295 (Illegible)	27.	4×10^{-3}	25° Blende Diaphragm mit Thermoel. Diaphragm with thermoelement	
Glühlampe 5 cm näher zur Blende.						
18.12	$15^{??}$ 15^{20}	297	21 / 23.5	1×10^{-4} 6×10^{-3}	21 Blende Thermo... nach Ventilumstellung	[illegible] "
18.12	19^{25}	297	28	4×10^{-3}	25°C an Blende mit Fühler	[illegible]
19.12	$7^{??}$	295	25.3	4×10^{-3}	21°C	[illegible]

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7. TEST INSTRUCTION/TEST REPORT FOR TEST SERIES 2

Project Definition:
H Schwenke (2x), H. Herzberg, H. Wonglotz
H Mundling (4x), Messung, Fr. Leil,
H. Czaika (je 4x), H Braun (4x).

MBB Report: TN RT 353-1/78

Author: H. Czaika

Division: RT 354

Title: Test Instructions
Ground Tests for Investigating
the MV_2 anomaly
Second test series

Date: 1/18/78

23 Pages
Appendix A
1 page
Appendix B
7 pages
Appendix C
3 pages

Summary: Extension of test report:
Experimental values recorded on February 13, 1978

Change:
3.5.1. was added, page 23.

Author
Czaika

Division
RT 353

1. <u>Summary</u>

In order to investigate the MV2 anomaly **(TN RT 353-7/77)** hot runs with the 10 N-Engine were carried out.(in the atmosphere).

In the present document we specify the required steps for preparing and carrying out the hot run tests.

Test 1: Reference test for which no blockage is expected

Test 2: Hot run test for which N_2O_4 is used with the chemical composition specified in item 2.3.2.2.

Test 3: Is only used if during Test 2 no blockage in the N_2O_4 conveyance system occurs. In this hot run the Fe-Ni-Nitrate component in the N_2O_4 is increased.

2. <u>Data on the Test Specimen and Test Installations for the Hot Run.</u>

2.1. Test Specimen:

- 10 N-Engine **SYS 2451 Bt. Nr. 35**
  with valve **Bt. Nr. 44**

- Original fuel conveyance lines (line cross section and length) with the filter and the diaphragm according to the HG system engine H4 (Sketch Page 8) in the conveyance line between hand valve OX 4 (BR 4) and the engine.

2.2. Test Configuration:

The test configuration (sketch page 8) is done according to **TN RT 35-7/77** . All of the components of the conveyance system and the fuel containers are cleaned according to **TN-RT 353-1/77** and the cleanliness is demonstrated using the Millipore method (without QS documentation.

2.3. Fuels and Fuel Amounts

2.3.1. MMH: (Demonstration not required)
Amount of fuel to be filled: 6300 g
(for an expected test time of 3 x 24 min)

2.3.2. Distilled N_2O_4 with the following chemical composition

2.3.2.1. Hotline 1

	Nominal value according to MIL-Spec 26 539	Actual values
N_2O_4 wt %	≥ 99,5	99,34
H_2O Equival. wt %	≤ 0,17	0,11
Solids mg/l	≤ 10	

The solid fraction is determined quantitatively through 1μ Millipore filters using 200 g N_2O_4. Particle distribution on the filter is not determined (see test sequence).

The amount of fuel to be filled: 3500 g
Number of particles, actual value: Cleanliness Class 2 according to SAE
January 20 1978
signature:Muller

2.3.2.2. Hot run 2

Distilled N_2O_4 with the following chemical composition is used: (see data of TN-RT 353-7/77)

* HNO_3 wt%: 0.64 — * 98 wt. % x dest. (Purity see item 2.3.2.1.)
1 wt. % H_2O dest
H_2O free wt. %: 0.02 — 1 wt. % Kaltron MDS 113
20 mg/l Nitrate mixture: 50 wt % Fe-nitrate
50 wt.% Ni-nitrate

HNO_3 +free H_2O gives an H_2O equivalent of 0.11 wt. %.

Responsible for Item 2.3.2.2. RT351 Mrs. Keil Keil

Total amount of impurities N_2O_4 : 3500 g

N_2O_4 dest.	=	3430 g	(± balance air)
H_2O dest.	=	35 g	5 g
Kaltron 113 MDS.:	=	35 g	

Fe-Nitrate = 24.2 mg.
Ni-Nitrate = 24.2 mg.

2.3.2.3. Hot Run 3 (is performed if no blockage is found during Hot Run 2.

Distilled N_2O_4 with the chemical composition as under Item 2.3.2.2., but the Fe-Ni-Nitrate fraction is increased to 40 mg/l
For 3500 g N_2O_4 we find:

Fe-Nitrate = 48.4.mg.
Ni-Nitrate = 48.4 mg.

2.3.3. Filling of the N_2O_4 and MMH-containers.

2.3.3.1. MMH-Container:

Fill the MMH using a 1μm Millipore . Filter and filling is controlled by weighing. Ventilation on the container is only opened if over pressure exists in it in order to avoid entry of air.

2.3.3.2. Filling of the N_2O_4 container

Filling of distilled N_2O_4 through a 1μm Millipore filter and filling is checked by weighing. Ventilation of container only when over pressure exists in it in order to avoid penetration of air. When producing the mixture for Test 2 and Test 3, impurities (H_2O and freon) are mixed by weighing (Filter 2μm). A 20 kg balance is used for this (1 scale division = 5g).

Sequence:

- Determination of the empty weight GB of the N_2O_4 - container (residual N_2O_4 is emptied) GB = kg
- filling of the Fe-Ni-Nitrate mixture weighed separately on an analysis balance.
- filling of the Kaltron 113 MDS or the amount of water separately on an analysis balance.
- weighing of the distilled N_2O_4
- mixing of components by shaking the closed container
- before filling in the N_2O_4 into the container for hot run 3 the container is cleaned according to **TN-RT 353-1/77**

2.4. Measurement location plan

Measurement	Range	Recording*	Remark
$\Delta p1$ (Fi)	0 - 7 bar	V, D, A	ged. 100 μF
$\Delta p2$ (Bl)	0 - 13 bar	V, D, A	ged. 100 μF
P_L	0 - 20 bar	V, D, A	ged. 100 μF
P_C	0 - 9 bar	V, D, A	ged. 100 μF
$\dot{m}_O$	Hz	D, A	
$\dot{m}_B$	Hz	D, A	
Valve signal Engine		V	
Time			
Pressure mark		D, A V	

* V-Visicorder, D-Printer, A-Reading.

Pressure measurement transducers	$\Delta p1$	CEC TYP 4 - 351 - 002
	$\Delta p2$	CEC TYP 4 - 351 - 005
	P_L, P_c	CEC 4 - 326 - L 226
Turbine flux meter	COX 6-00 N_2O_4	Turb.Nr. 7191
	COX 6-00 MMH	Turb.Nr. 15732
Calibration of pressure transducers using a		2µm Filter (nor)

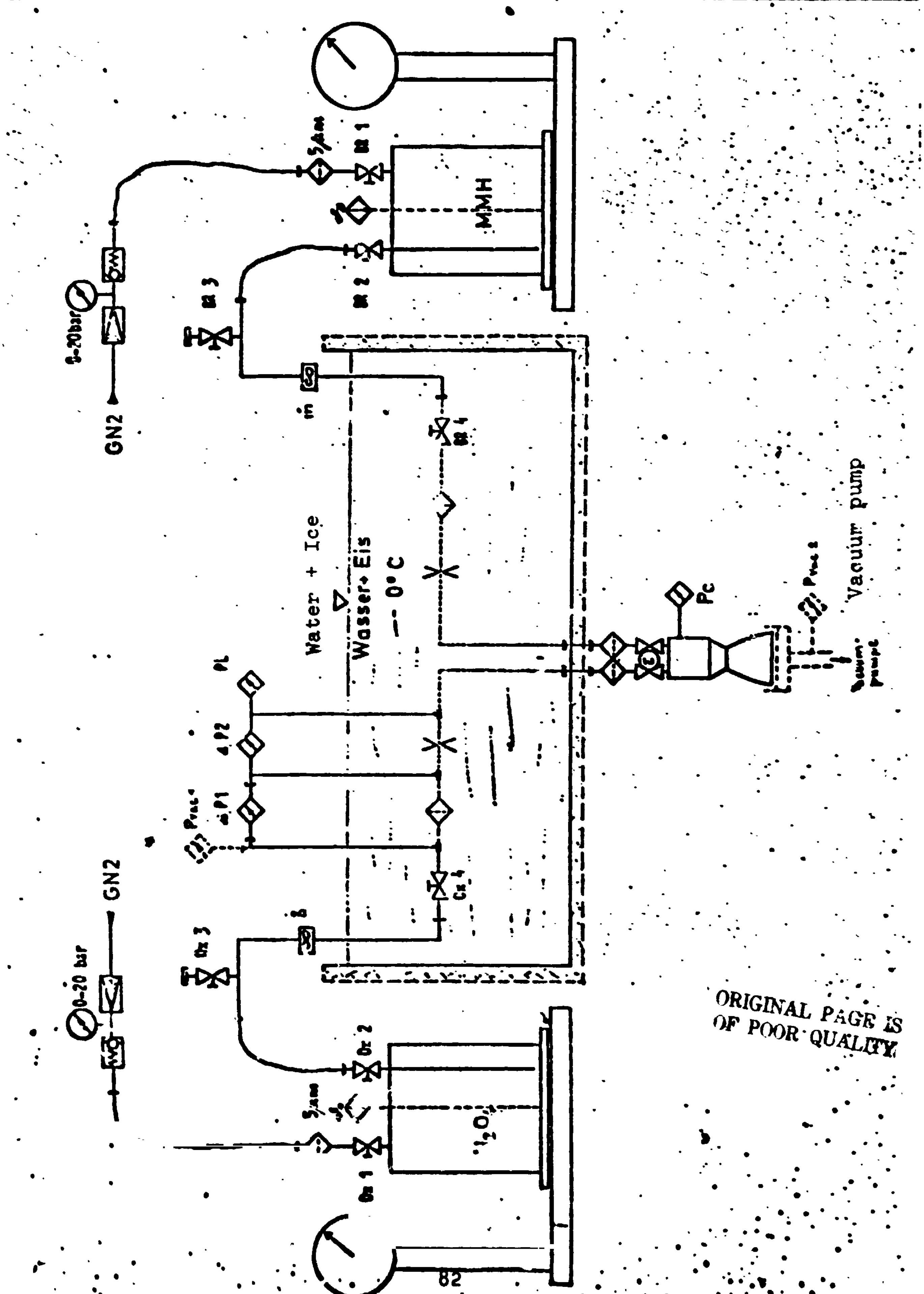
3. Test Sequence

3.1. Preparations

- Addition of the fuels (Item 2.3.3.)
- Calibration and installation of transducers
- functional test of engine valve
- air tightness test of the entire conveyance system by applying a load through HV-OX3 (BR3) and GN2 = 10 bar (Filter 2µm)
- filling of the basin with ice water
- pressurization of the N_2O_4 container at P_T (HV-OX2 "CLOSED")

Pressure balance	P_E N_2O_4	= 13,30	bar
	diaphragm	= 5,0	bar
	Δ p FÖS	= 0,5	bar
		18,80	bar
	P_T =	17,80	atg

- for hot run 2 + 3, adjust values from hot run 1
- evacuation of the N_2O_4 conveyance system by means of HV-OX3, ($\triangleq$ 0,1 Torr) HV-OX4 "ON"
- filling of the N_2O_4 conveyance system by opening hand valve Ox 2.



ORIGINAL PAGE IS
OF POOR QUALITY

- removal of a cleanliness sample with a Millipore adapter with 1µm - Filter and a floor mount of 200 g on the manual valve OX3.
- qualitative check of the filter for particle amount, particle size and particle identification.
- pressurization of the MMH container at PT (HV-BR 2 "CLOSED")

Pressure balance	$P_{E\ MMH}$	-	14,10	bar
	diaphragms	-	4,5	bar
	Δp FÖS	-	0,3	bar
			18,9	bar
	P_T*		17,9	atg

* For hot runs 2 + 3 adjust values from hot run 1 .

- Evacuation of the MMH-co veyance system using (≤0,1 Torr) HV-BR 4 "CLOSED"
- Filling of the MMH-conveyance system by opening handvalve BR2.

3.2. Nominal operating conditions for the engine

$\dot{m}_{ges}$	=	3,54	g/s	
. .	=	1,64	g/s	
$\dot{m}_{N_2O_4}$	=	2,20	g/s	(Turb.Nr. 7191)
$\dot{m}_{MMH}$	=	1,34	g/s	(Turb.Nr. 15732)
P_{E-O}	=	13,3	bar	
P_{E-B}	=	14,1	bar	
P_C	=	8,7	bar	

3.3. Hot Run 1 (Reference test for which no blockage is expected)
Test no. 02-2953/1 1/20/78

3.3.1. Manual recording:

			Nominal value	
Fuel temperature in the tank	$\vartheta_{N_2O_4}$	:	11	°C
	ϑ_{MMH}	:	6	°C
Ice water temperature	ϑ_{H_2O}	:	2	°C
Balance Reading	N_2O_4	:	10,965	kg
	MMH	:	13,68	kg
Adjusted tank pressurization	N_2O_4	:	19,3	atg
	MMH	:	18,2	atg.

- Equalization of differential pressure measurement transducers.
- Check: Manual valve

Ox 1 / BR 1	"ON"
Ox 2 / BR 2	"ON"
Ox 3 / BR 3	"OFF"
Ox 4 / BR 4	"ON"

3.3.2. Engine Ignition:

- 2 seconds before engine ignition - Visicorder "ON" 2
- upon engine ignition start time and print out values at time intervals of 2 minutes (2x)
- check the mass throughputs: if necessary interrupt engine operation (stop the time), if deviations in $\dot{m}_{ges}$ nom and r nom are found. Throughput correction is made by changing the tank pressures.
- observation of differential pressures
- observation of temperature load on the engine, especially on the vacuum nozzle.

  Interrupt test for critical operating state.

3.3.3. Engine shutdown for the test time

t_{ges} = 1440 s Nominal time = 1440 second

- visicorder "OFF"
- manual recording:

	Nominal value
Engine temperature in the tank	ϑ N_2O_4 16 °C
	ϑ MMH 8 °C
Ice water	ϑ H_2O 2 °C
Balance reading	N_2O_4 7,680 kg
	MMH 11,810 kg
Adjusted values of tank pressurization	N_2O_4 19,3 atg
	MMH 18,2 atg

- reduction in P_{T-O} and P_{T-B}
- close handvalves OX 2 and BR 2
  OX 4 and BR 4
- empty N_2O_4 container

3.4. Hot run 2 (Test with contaminated N_2O_4 according to Item 2.3.2.2.)
Test No. 02-2953/2
January 20, 1978

3.4.1. Manual recording:

	Nominal value
Fuel temperature in the tank	ϑN_2O_4 : 8 °C
	ϑ MMH : 6 °C
Ice water	ϑH_2O : 2 °C
Balance reading	N_2O_4: 10,939 kg
	MMH : 11,808 kg
Adjusted values of tank pressurization	N_2O_4: 19,3 atg
(see adjusted values for hot run 1)	MMH : 18,2 atg

- equalization of differential pressure transducers

  Check manual valves:

Ox 1 / BR 1	"ON"
Ox 2 / BR 2	"ON"
Ox 3 / BR 3	"OFF"
Ox 4 / BR 4	"ON"

3.4.2. Engine Ignition

- 2 seconds before engine ignition - Visicorder "ON" 1
- start time upon engine ignition and print out values at 1 minute intervals (2x). Shorten intervals if there are throughput changes.
- Observe temperature load on engine especially on the vacuum nozzle.

  Discontinue test for critical operating conditions.
- Observation of differential pressures, injection pressures and flux readings in order to evaluate possible throughput changes and whether these are caused by the beginning of blockage.
- allow blockages in the N_2O_4 conveyance system to increase as long as the operating state of the engine is not critical because of the displacement.of the mixing ratio.

3.4.3. Engine shutdown

3.4.3.1. After blockage of the N_2O_4 conveyance system has occurred Preference value

$$\dot{m}_{N_2O_4} \quad 0{,}46\ \mathrm{g/s} \;\hat{=}\; \qquad \mathrm{Imp/s}$$

(according to $20\ \% \cdot \dot{m}_{N_2O_4}$ Nom.)

3.4.3.2. After an operating time of

$$t = 1440\ \mathrm{s}$$

- Visicorder "OFF"

Recording:

	Nominal value	
Fuel temperature in the tank	$\vartheta_{N_2O_4}$: 8	°C
	ϑ_{MMH} : 6	°C
Ice water temperature	ϑ_{H_2O} : 2	°C
Balance reading	N_2O_4 : 10,314	kg
	MMH : 11,320	kg
Adjusted tank pressurization	N_2O_4 : 19,3	atg
	MMH : 18,2	atg
Test time	t : 360	s

- Reduction in P_{TO} and P_{TB}
- Close manual valves OX 2 and BR 2
  OX 4 and BR 4
- if blockage occurs during a hot run:
  further sequence according to item 3.4.4.
- if no blockage occurs during the hot run:
  continue sequence according to item 3.5.

3.4.4. Blockage in the N_2O_4 conveyance system

- from the changes in the differential pressures or the change in the injection pressure, determine the location of the blockage (filter, diaphragm, injection system)

- close differential pressure can Δp^1 with $\Delta p_1, p_2, p_3$ closed and close the connections using blind screw connections.
- let ice water run out of the pan.
- open HV-3R4 and evacuate MMH conveyance system through HV-BR3 ($p \leq 0{,}1$ Torr)

- Rinse the MMH conveyance system with N_2 with open engine valve through manual valve BR3 (flux reading BR is observed).
- fuels are removed from the engine and the conveyance system for the most part. (Manual valves Ox4 and BR4 in the conveyance system are closed), by connecting a gas jet pump through an adapter over the vacuum nozzle of the engine (valve open).
- after this connect the adapter to a vacuum pump.
- Manometer P_{vac} is connected ahead of the filter.
- Open the engine valve and evacuate the conveyance system over 336 hours ($P_{vac\,1}$ + $P_{vac\,2}$ is recorded).

$$P_v \leq 10^{-2} \text{ Torr}$$

- surrounding temperature in the pan and the temperature on the filter are recorded.
- temperature on the engine valve is checked. At the beginning record at intervals of 10 minutes.
  - ° if 95°C is exceeded close the engine valve and open it again after the temperature drops and then record P_v .
  - ° after the end of the evacuation time close engine valve and close off adapter and vacuum pump (calibrate Δp_1, Δp_2, P_L, P_L
  - ° close manometer P_{vac} and connect pressure can Δp_1 pressure cans Δp_2, P_L, P_t are connected.

3.4.4.1. Repetition of hot run 2 Test No. 02-2955

February 2, 1978

- pressurization of N_2O_4 and MMH containers adjusted values as under 3.4.1.
- evacuation of the HV-Ox 4 or MMH conveyance system (manual valves in the conveyance system 2 and HV-BR 4 are open) through HV-Ox 3/BR 3 ($\leq$ 0,1 Torr)

- fill the N_2O_4 conveyance system:

  Manual valve on the tank HV-Ox 2 "OPEN"
  Manual valve on the conveyance system HV-Ox 4 "OPEN" (Check)
- fill the MMH conveyance system:
  Manual valve on the tank HV-BR 2 "OPEN"
  Manual valve on the conveyance HV-BR 4 "OPEN" (Check)
- Manual Recording:

			Nominal value	
Fuel temperature in the tank	$\vartheta_{N_2O_4}$	:	12	°C
	ϑ_{MMH}	:	12	°C
Ice water	ϑ_{H_2O}	:	2	°C
Balance reading	N_2O_4	:	10,274	kg
	MMH	:	11,185	kg
Adjusted values of tank pressurization (adjusted value Item 3.4.1.)	N_2O_4	:	17,8	atg
	MMH	:	18,2	atg

- equalization of differential pressure transducers
- check: Manual valves

Ox 1 / BR 1	"ON"
Ox 2 / BR 2	"ON"
Ox 3 / BR 3	"OFF"
Ox 4 / BR 4	"ON"

3.4.4.2. Engine ignition

- 2 seconds before engine ignition - Visicorder "ON" = 1 cm/s
- start time at engine ignition and print over time intervals of 1 minute (2x). Shorten time intervals for throughput changes.
- Observe: temperature load on engine, especially on

the vacuum nozzle.

interrupt test for critical operating conditions.

- Observe differential pressures, injection pressure and flux reading in order to evaluate possible throughput changes and whether these are caused by a (beginning) blockage.
- blockages which occur in the N_2O_4 conveyance system are allowed to increase as long as the engine operating state is not critical because of displacement of the mixing ratio.

3.4.4.3. Engine shutdown

3.4.4.3.1. - for blockage of the N_2O_4 conveyance system (same blockage as before evacuation)

3.4.4.3.2. - after an operating time according to the available N_2O_4

(Filled in N_2O_4 minus consumed N_2O_4 for hot run2 =remainder for repetition)

- visicorder "OFF"
- Recording:

			Nominal value	
Fuel temperature	$\vartheta_{N_2O_4}$	:	9	°C
	ϑ_{MMH}	:	9	°C
Ice water	ϑ_{H_2O}	:	2	°C
Balance reading	N_2O_4	:	7,694	kg
	MMH	:	9,330	kg
Temperature pressurization adjusted values	N_2O_4	:	17,3	atg
	MMH	:	18,2	atg
test time	t	:	1347	s

- reduction in P_{TO} and P_{TB}
- closed manual valve Ox 2 and BR 2
  . Ox 4 and BR 4 .
- if blockage is successfully removed, empty Ox and BR conveyance systems.
- in the case of failure rinse MMH conveyance system with GN 2 (2μm Filter) . N_2O_4 conveyance system is rinsed through a 2μm Filter using about 60°C warm distilled water. The rinse water is captured in a suitable clean container.

3.5. Hot Run 3 (test with contaminated N_2O_4 according to item 2.3.2.3)

This hot run is carried out if no blockage occurs for Hot Run 2.
Hot Run sequence the same as for Hot Run 2 (Item 3.4.1.)

3.5.1. Hot Run 3

When Hot Run 2 is repeated (item 3.4.4.1.) we found no blockage after about 1300 seconds (Ox-Tank empty)

After this an additional test Number 02-2956 was carried out with N_2O_4 , using the composition of 3.3.3.2.

Surprisingly blockage occurred after 100 seconds on the filter (see graphed figures of test results).

MESSERSCHMITT-BÖLKOW-BLOHM
Gesellschaft mit beschränkter Haftung
Außenstelle Lampoldshausen

Projekt / Auftrag
Anhang A zu TN-RT353-1/78
Project Appendix A to:

Division RT 351
Aussteller
Author

Benennung / Stichwort / Type / Z.-Nr.
Name: Tuning Diaphragm Procedure
Vorgaben Abstimmblenden

November 17, 1977 Date 17.11.77
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T.T. Nr 163

Order	1	2	3	4	5	6
Abt.						
Name	G. Braun					

Regarding ground tests for investigating the MV2 anomalies according to TN-RT 35 -7/77.
Betr. Bodentests zur Untersuchung der MV2-Anomalien gemäß TN-RT 35-7/77

Abstimmblenden.
Tuning Diaphragms

Gemäß TN RE 31-65/74 (Abstimmung WG MV2)
According to TN RE 31-65/74 (Tuning of:)
ergeben sich folgende Flußzahlen für die Blenden
the following flow number result for the diaphragms:

$$FN_{Bl_{ox}} = 0{,}0579 \text{ mm}^2$$

$$FN_{Bl_{br}} = 0{,}0493 \text{ mm}^2$$

Definition: $FN = \dfrac{\dot m \;[\text{g/s}]}{14{,}142\sqrt{\rho \cdot \Delta p}} \text{ mm}^2$ (ρ: g/cm³, Δp: bar)

oder or

$$\Delta p = \left(\frac{\dot m}{FN}\right)^2 \cdot \frac{1}{200 \cdot \rho} \text{ bar}$$

Nominaldurchsätze:
Nominal throughputs

$F = 10\ N$

$I_{sp} = 2825 \dfrac{Ns}{kg}$ $\quad r = 1{,}645$

$\dot m_{WG,1} = \dfrac{\dot m_{ges}}{\cdot I}$ (FN, konstant / approx.)

$$\dot m_{ges} = \frac{10}{2825} = 0{,}00354 \text{ kg/s}$$

$$= 3{,}54 \text{ g/s}$$

Specified (illegible)
Vorgaben
W. i. [illegible] W.V

MMH $\dot m_{br} = \dfrac{\dot m_{ges}}{r+1} = \dfrac{3{,}54}{2{,}645} = \underline{\underline{1{,}34 \text{ g/s}}}$ $\quad$ 1,43 ~~1,3~~ %

N_2O_4 $\dot m_{ox} = r \cdot \dot m_{br} = \underline{\underline{2{,}20 \text{ g/s}}}$ $\quad$ 1,83 ~~[illegible]~~

$$\Delta p_{br} = \left(\frac{1{,}34}{0{,}0493}\right)^2 \cdot \frac{1}{200 \cdot 0{,}879} = \underline{\underline{4{,}2}} \text{ bar}$$

$$\Delta p_{ox} = \left(\frac{2{,}20}{0{,}0579}\right)^2 \frac{1}{200 \cdot 1{,}446} = \underline{\underline{5}} \text{ bar}$$

QS Demonstration

for: Ground tests for investigating the MV_2 anomaly

Name : HG N_2O_4 Container

Item No: 8720

Component No.:

Fabrication No.:

To:

Nominal value for cleanliness demonstration Class 1 according to SAE

Actual value: Date: 7/17/78 RC34
(illegible)

Nominal value for operating pressure demonstration:

Actual:

Nominal value for air tightness demonstration:

Actual:

Media for cleanliness demonstration: Isoproponol

Media for operating pressure demonstration

Media for air tightness demonstration

GN_2, LAM Supply Network

The nominal values with "QS" have to be demonstrated by the QS.

-Munding- -Braun-

for Ground tests for investigating the MV_2 anomaly

Name: N_2O_4 Side Test Configuration

Item No.:

Component No.:

Fabrication No.:

Filter MQ SK 2480-22 BT Housing Nr. 20/21
Turbine Model LF 6-60 Serial No. 7191

To: HG tube 1/8" x 0.01" x 1000 mm long
Manual valve: Nupro SS 4H.

Nominal value for cleanliness demonstration Class 1 according to SAE

Actual value: Date: 7/17/78 RC34
(illegible)

Nominal value for operating pressure demonstration:

Actual:

Nominal value for air tightness demonstration:

Actual:

Media for cleanliness demonstration: Isopropanol

Media for operating pressure demonstration

Media for air tightness demonstration N_2 LAM Supply Network

Chemical purity with tubes.....tested
Nominal: Residual amounts of.....ppm
The nominal values with "QS" have to be demonstrated by the QS.

-Munding- -Braun-

Appendix B to
TN-RT353-1/78 Author: Herzberg
QS Demonstration Date 1.16.78

for: Ground Tests for investigating the MV_2 anomaly

Name: MMH Side Test Configuration

Item No.:

Component No.:

Fabrication No.:
Turbine: Model = LF 6-00 Serial No 15732
To: HG tube 1/8" x 0.01" x 1000 mm long
Manual valve: Nupro SS 4H.

Nominal value for cleanliness demonstration Class 1 according to SAE

Actual Value: Date 7/17/78 RC34
(illegible)

Nominal value for operating pressure demonstration:

Actual:

Nominal value for air tightness demonstration:

Actual:

Media for cleanliness demonstration: Isopropanol
Media for operating pressure demonstration:
Media for air tightness demonstration: N_2 LAM Network

The nominal values with "QS" have to be demonstrated by the QS.

-Munding- -Braun-

for: Ground tests for investigating the MV_2 anomaly

QS Demonstration

Name: N_2O_2 HG Tank filling line

Item No.: 8694 Ku 6-N_2

Component No.:

Fabrication No.:

To:

Nominal value for cleanliness demonstration Class 1 according to SAE

Actual value Date 7.2.78 RC34

(Illegible)

Nominal value for operating pressure demonstration

Actual:

Nominal value for air tightness demonstration:

Actual:

Media for cleanliness demonstration: N_2 line LAM

Media for operating pressure demonstration

Media for air tightness demonstration

Chemical purity with tubes.......tested

Nominal: Residual amounts of .....ppm

The nominal values with "QS" have to be demonstrated by the QS.

- Munding - -Braun-

Name: GSP drive line A pog for MMH pressurization

Item No: 5470

Component No.:

Fabrication No.:

To:

Nominal value for cleanliness demonstration Class 1 according to SAE

Actual value: 7/12/78 RC34
(illegible)

Nominal value for operating pressure demonstration:

Actual:

Nominal value for air tightness demonstration:

Actual:

Media for cleanliness demonstration: N_2 LAM Supply Network

Media for operating pressure demonstration

Media for air tightness demonstration

Chemical purity with tubes.....tested

Nominal: Residual amounts of....ppm

The nominal values with "QS" have to be demonstrated by the QS.

QS Demonstration

for ground tests for investigating the MV_2 anomaly

Name: MMH - HG Container line

Item No: 8693 Ku 5 14

Component
No:

Fabrica-
tion No.

To:

Nominal value for cleanliness demonstration: Class 1 according to SAE

Actual Date: 7/02/78 RC34 (illegible)

Nominal value for operating pressure demonstration:

Actual:

Nominal value for air tightness demonstration:

Actual:

Media for cleanliness demonstration: Isopropanol

Media for operating pressure demonstration:
Media for air tightness examination:
Chemical purity with tubes......tested
Nominal: Residual amounts of .....ppm
The nominal values with "QS" have to be demonstrated by the QS.

-Munding- -Braun-

for: ground tests for investigating the NV_2 anomaly

Name: N_2O_4 HG Container Line

Item No.: 8692 Ku 4 13

Component
No: 2

Fabrication No.:

To:

Nominal value for cleanliness demonstration: Class 1 according to SAE
Actual Date 7.12/78 RC34 (Illegible)

Nominal value for operating pressure demonstration;

Actual:

Nominal value for air tightness demonstration: Isopropanol

Actual:

Media for cleanliness demonstration:

Media for operating pressure demonstration:

Media for air tightness demonstration:

Chemical purity with tubes......tested
Nominal: Residual amounts of .....ppm
The nominal values with "QS" have to be demonstrated by the QS.
-Munding- -Braun-

Division
RT 353

Evacuation of Conveyance System
MV2 Anomaly Test Results

Author
Braun

Date 1/20/78

The temperature on the engine is measured with a measurement bridge using the resistance of the coil.

$$R_{max} = 331 \text{ Ohm} \triangleq 95^{\circ}C$$

Temperature of the Ox-Diaphragm, nominally 28°C
Operating voltage for Engine 27 Volt DC
Total evacuation time 336 hours (FS of 1.23.78)

Monitoring Date	Time	Temperature °C Diaphragm surroundings	Diaphragm	Vacuum [bar] of diaphragm	[Torr] and Engine	Resistance of the Coil [Ohm]	Remark	Name
20.1.	17^{25}	-	-	-	-	254		
	17^{35}	15	-	-	3×10^{-2}	-		
	18^{15}	22	-	-	4×10^{-2}	298	Engine open	
	21^{30}	26,5	24	-	6×10^{-3}	298		
21.1.	7^{45}	27,5	24	-	6×10^{-3}	302		
	12^{10}	27,5	24	0,2	6×10^{-3}	302		
	16^{05}	29	25	0	6×10^{-3}	302	Lamp moved 4 cm back	
	20^{10}	29	25	0	7×10^{-3}	302		
22.1.	8^{05}	29,5	24,5	0	5×10^{-3}	302	Lamp moved 4 cm back	
	13^{30}	29,5	28	-	5×10^{-3}	302		
	19^{20}	29,5	28	0	5×10^{-3}	302		

Evacuation of Conveyance System
MV2-Anomaly Test Results

Monitoring Date	Monitoring Time	Temperature °C Diaphragm surroundings	Temperature °C Diaphragm	Vacuum [bar] of diaphragm	Vacuum [Torr] Engine	Resistance of the Coil [Ohm]	Remark	Name
23.1.	19^{30}	27	28,5	0	5×10^{-3}	302		
24.1.	8^{00}	28,5	27,5	0	5×10^{-3}	303		
	11^{55}	18	18	0	5×10^{-3}	305		
	13^{10}	24,5	28,5	0	5×10^{-3}	305		
	16^{25}	29,5	28	0	5×10^{-3}	306		
25.1.	7^{55}	29,5	28,5	0	5×10^{-3}	304		
	11^{55}	29,5	27	0	5×10^{-3}	305		
	16^{15}	28	26,5	0	5×10^{-3}	299		
26.1.	8^{00}	28	26	0	5×10^{-3}	304		
	12^{00}	29,5	27	0	5×10^{-3}	304		
	17^{00}	29	26,5	0	5×10^{-3}	304		
27.1.	8^{15}	28	25,5	0	5×10^{-3}	304		
	12^{00}	26	25	0	5×10^{-3}	300		

Evacuation of Conveyance System MV2 Anomaly Test Results

Author
Braun

Monitoring Date	Time	Temperature °C Diaphragm surroundings	Temperature °C Diaphragm	Vacuum [bar] of diaphragm	Vacuum [Torr] Engine	Resistance of the coil [Ohm]	Remark	Name
28.1.78	8.30	24		~0,09	4×10^{-3}	296		gez. [illegible]
	17.40	24,5		~0,09	5×10^{-3}	296		-"-
	18.15	24,5	22,5	0,97-	5×10^{-3}	299		" Herberg
29.1.78	8,50	25,0	23,0	0,97-	4×10^{-3}	296		" "
	18.30	27	25	0,97-	4×10	297		gez. Baun
30.1.78	8.00	25,5	25	0,97-	4×10^{-3}	298		gez. Herberg
	16.00	26,5	25,5	0,97-	4×10^{-3}	300		-"-
31.1.78	8.00	25	23	0,97-	4×10^{-3}	297		-"-
	16.30	26	25	0,97-	4×10^{-3}	299		-"-
1.2.78	8.00	27	25,5	0,97-	4×10^{-3}	301		-"-
	16.30	29,5	27	0,97-	4×10^{-3}	302		-"-
2.2.78	8.10	29,5	27,5	0,97-	4×10^{-3}	303		-"-
	10:15	Engine	Close	Vacuum pump off				-"-
	10.20	Pump	On	6×10^{-3} Engine on				
	13.00	30	27,5	—	4×10^{-3}	304		-"-

ORIGINAL PAGE IS
OF POOR QUALITY